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Breathe and sleep:

A relaxation technique to prevent the decrease in pre-competition sleep quality.

by

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Abstract

Athletes tend to sleep less than recommended for peak performance, especially before competition. Therefore the aim of this study was threefold: a) to examine if there is a difference in athletes´ subjective and objective sleep quality and quantity between pre-training and pre-competition nights, b) to evaluate if a relaxation-intervention (breathing-technique) can prevent the decrease in athlete´s pre-competition sleep quality and quantity, and c) to test the advantages and disadvantages of different subjective and objective instruments for the assessment of sleep quality and quantity.

Twenty competitive athletes (7 female; M_{age}= 22.55 years, SD = 4.45) were divided to an experimental (10) or control group (10) in a two-group quasi-experimental design. Sleep parameters were measured at three different times for 2 nights via sleep-log and actigraphy.

The results revealed no differences in subjective and objective sleep parameters between training and competition conditions. The breathing-intervention showed also no significant influence on athletes´ sleep quality and quantity. Nevertheless, athletes sleep less than recommended. Finally, significant differences between subjective and objective measurements were found, and the results did not support the "first-night-effect" by using actigraphy.

In conclusion, coaches, sport-psychologists and the overall surrounding staff of athletes should try to educate them as good as possible about sleep and support them to improve sleep quality and quantity. Further research is needed to discover the concrete circumstances of sleep deprivation prior to competitions.

Keywords: sleep, athletic-performance, soccer, actigraphy, sleep-deprivation, breathing

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Introduction

> "Sleep, and enough of it, is the prime necessity. Enough exercise, and good food and enough, are other necessities. But sleep—good sleep, and enough of it—this is a necessity without which you cannot have the exercise of use, nor the food."
>
> - Edward Everett Hale (1822 - 1909)

Elite athletes spend around 6.8 hours on sleep per night which is too less according to the recommended 8 hours of sleep per night (Natale, Adan, & Fabbri, 2009; Lastella, Roach, Halson, & Sargent, 2015). Sleep is seen as important for athletic performance, and therefore considered as a good reason to illuminate the relationship between sleep and the athlete. Although sleep is seen as an essential component for athletes to prepare for functioning in the subsequent awake period, little is known about athlete´s sleep, especially around competitions (Juliff, Halson, & Peiffer, 2015). Subsequently it was found that over two-thirds of elite athletes in Germany and Australia experienced at least once per year poor sleep quality in the night before competition (Erlacher, Ehrenspiel, Adegbesan, & Galal El-Din, 2011; Juliff et al., 2015). Previous studies confirmed the hypothesis that sleep-deprivation might affect the physiological and cognitive mechanisms, related to athletic performance (Abedelmalek, Chtourou, Aloui, Aouichaoui, Souissi, & Tabka, 2013; Taheri & Arabameri, 2012). From there the decrease in sleep quality and quantity prior to competitions should be prevented. Hence, the main purpose of this thesis is the successful prevention of the decrease in sleep quality and quantity prior to competitions by using a relaxation-technique. These is complete by the replication of previous findings about sleep deprivation prior to competitions in a non-elite-sports population and the evaluation of different methods to assess sleep quality and quantity.

Literature review

Sleep

Carskadon and Dement, (2011) defined sleep as a reversible behavioural state in which individuals are perceptually disengaged from and unresponsive to their environment. Neuronal as well as physiological points of view exists about the mechanism of sleep. From a neuronal view point it can be seen that the difference between wakefulness and sleep depends on the activation or inhibition of several systems in the brainstem and the hypothalamus (Coulon, Budde, & Pape, 2012). In connection to this, it is proposed that the ventro-lateral preoptic nucleus of the hypothalamus initiates sleep onset through inhibition of the cholinergic, noradrenergic, and serotonergic arousal systems in the brainstem (Pace-Schott & Hobson, 2002). The physiological view point offers the differentiation of sleep itself into two primary states based on physiological parameters as electroencephalography (EEG), which are on one hand rapid eye movement sleep (REM) and on the other hand non-rapid eye movement sleep (NREM) (Halson, 2014). Moreover, the NREM-state itself can be divided into three subcategories, composed of NREM1, NREM2, and NREM3 (Maurer, Weeß, & Schredl, 2013). Sleep is introduced by NREM1, with a low threshold for awakening, and passes NREM2, into a more stable sleep-phase. The next phase, NREM3 is defined as delta-sleep, or deep sleep and is characterised with a high threshold for awakening. All NREM-phases have a minimal or low mental activity in common. On the contrary the subsequent REM-phase is characterized by high EEG-activity, cardiorespiratory irregularities, little muscle contraction and rapid eye movement. These different phases define the sleep-cycle, which lasts 90-120 minutes and is repeated during the sleep (Carskadon & Dement, 2011; Maurer et al., 2013). However the first sleep cycle lasts only 70-100 minutes and also includes only a view minutes of REM-sleep, whose duration increases from cycle to cycle over the night (Carskadon & Dement, 2011).

Importance of sleep

In the general population sufficient sleep is an important resource for the psychological and physiological wellbeing. This is because of several mechanisms who are directed by sleep, as the restauration of tissue and the replenishment of cerebral glycogen stores for the glycogenolysis during waking, which optimize the capability of the nervous system to respond to stimuli (Benington & Heller, 1995). Also the two primary states of sleep have been found as important for the consolidation of newly acquired information in memory. One on hand, slow-wave-sleep (SWS) integrates newly encoded memories with pre-existing long-term memories. On the other hand, REM-sleep might act to stabilize the transformed memories by permitting undisturbed synaptic consolidation (Diekelmann & Born, 2010).

At a cellular level sleep may be a process of detoxification, because the glymphatic system, using convective flow between the cerebrospinal fluid and interstitial fluid to remove toxic metabolites from the brain, is strongly stimulated by sleep (Xie et al., 2013). The sleep-promoting substance uridine may contribute to recover the activity of neurons, so that sleep can be seen as process of neuronal restitution (Inoué, Honda, & Komoda, 1995).

Furthermore, most immune cells have their pro-inflammatory activity at night, which might have restorative effects on the immune and the endocrine system, (Allada & Siegel, 2008; Bollinger, Bollinger, Oster & Solbach, 2010).

Besides the above mentioned benefits, sleep plays an important role for the processes influenced by sleep, which are important for the athlete´s performance (Bird, 2013). For example Walker, Brakefield, Morgan, Hobson, & Stickgold, (2002) showed with a finger tapping task that after a night of sleep the participants increased in motor speed without loss accuracy by 20%, while a similar time during wake provided no significant benefit. This is a good example for the stabilization of motor memory via sleep, which improves athletes´

performance when the motor skill has been explicitly acquired (Landmann et al., 2014). Furthermore, the authors suggest in their review that the memory reorganisation especially during REM sleep fosters creativity.

Sleep and the athlete

The National Sleep Foundation for healthy sleep recommends 7-9 hours of sleep per night (Natale et al., 2009). In contrast to this recommendation a survey of 890 elite South African athletes showed that three-quarters of athletes sleep only between 6 and 8 hours per night (Venter, 2012). However, this study was only based on subjective measures, a better insight into the sleep-wake behaviours of elite athletes was provided by a succession of nine studies with 124 participants measuring sleep via self-reported sleep diaries and wrist-actigraphy (Lastella, Roach, Halson, & Sargent, 2015). The combination of subjective and objective measures showed in line with Venter (2012) that athletes went to bed at 22:59, woke up at 07:15, and obtained 6.8 hours of sleep per night. In this connection, athletes from individual sports spend less time asleep (6.5 vs. 7.0h) and had a lower sleep efficacy (85.9 vs. 86.4 %) compared to their team-sports counterparts. This illustrates that many athletes sleep below the recommended 8 hours of sleep per night. Other studies take a step further and suggest that athletes need even more sleep to promote recovery and restauration processes as a result of high training volumes and intensity, time consuming training timetables and psychological stress of competitions and training (Cummiskey, Natsis, Papathanasiou, & Pigozzi, 2013; Teng, Lastella, Roach, & Sargent, 2011). More practical, Scott (2002) suggests that it would be required for elite athletes, who train 4-6 hours per day, to sleep for 10-12 hours per night. Nevertheless, the optimal amount of sleep varies between athletes (Cummiskey et al., 2013; Walters, 2002), mainly due to a vast array of physiological and cultural differences (Aeschbach, Cajochen, Landolt, & Borbély, 1996; Aeschbach, Sher, Postolache, Matthews, Jackson, & Wehr, 2003). This variation makes it difficult to provide detailed recommendations for optimal sleep. In this regards, Bird (2013) suggested that athletes should sleep the amount of time that is required to feel awake and alert throughout the following day.

Total and partial sleep deprivation, sleep restriction and the athlete

Negative impacts on the processes influenced by sleep can expected if the optimal amount and quality of sleep is not reached. This includes also processes which are important for athletic performance. Hereby it is important to differ between total sleep deprivations and partial sleep deprivation. For clarification an athlete is partially sleep deprived, if he falls asleep later or wake up earlier than planned, so that the normal sleep-wake cycle is partially disturbed and restricted to less than or equal to six hours (Elmenhorst et al, 2008; Fullagar et al., 2015). It can be assumed that other thresholds than the six hours may be more appropriate to a minority of the population, depending on the inter-individual differences of optimal sleep (Cummiskey et al., 2013; Walters, 2002). Additionally, fragmental sleep can be seen as disrupted sleep caused by regular awakenings (Cote, Milner, Osip, Ray, & Baxter, 2003). In contrast, extreme cases of sleep loss, when athletes have a night without any sleep at all, are defined as total sleep deprivation. Whilst it may be seldom that athletes experience total sleep deprivation, their sleep before competitions for example could be reduced or fragmented.

The influence of sleep deprivation, partial sleep deprivation, and sleep extension on processes which are important for the athlete´s performance are discussed in the following section.

Total sleep deprivation

Irwin (see review, 2015) clearly stated that whereas sleep restores the immune system, sleep disturbance might negative influence adaptive and innate immunity which, in turn, entails repercussions for the athletic performance.

The afferent feedback after a night without sleep including lower muscle glycogen concentration and increased perceptual strain may lead to reduced recruitment of active muscle musculature (Skein, Duffield, Edge, Short, & Mundel, 2011), which can result in non-optimal pacing strategies and decreased total-sprint time of team-sport athletes. This is probably because of the missing replenishment of cerebral glycogen stores at night for the glycogenolysis during waking (Benington & Heller, 1995). More specifically, for athletic performance, other studies found that sleep deprivation decrease endurance performance (Azboy, & Kaygisiz, 2009; Bulbulian, Heaney, Leake, Sucec, & Sjoholm, 1996; Oliver, Costa, Laing, Bilzon, & Walsh, 2009). For example, Azboy and Kaygisiz (2009) studied the cardiorespiratory effects of one night without sleep on runners and volleyball players and concluded that maximal exercise capability is reduced, because the sleep loss decreased the time to exhaustion and exercise minute ventilation. When it comes to anaerobic performance, only Reilly and Piercy (1994) reported a negative effect of total sleep deprivation on athletic anaerobe performance. On the other side, there is a large body of evidence showing no effect of sleep deprivation on anaerobe performance (Souissi, Sesboüé, Gauthier, Larue, & Davenne, 2003; Taheri & Arabameri, 2012). For example, Blumert et al. (2007) illustrated in their study that no effects were found after a 24 hour sleep deprivation on weightlifters performance of snatch, clean and jerk, and front squat.

From a cognitive point of view there is evidence for the negative effect of total sleep deprivation on different mechanisms, which are considered as important for athletic performance (Lastella, Lovell, & Sargent, 2014). These mechanisms include alertness (Doran, Van Dongen, & Dinges, 2001), attention (Nilsson et al., 2005) and reaction time (Taheri & Arabameri, 2012). Furthermore, there are other psychological functions connected with athletic performance and influenced by sleep deprivation, as motivation (Blumert et al., 2007), memory consolidation (Walker & Stickgold, 2005), risk-taking behaviour (Killgore, Kamimori, & Balkin, 2011), and decision making (Harrison & Horne, 2000).

Partial sleep deprivation

Partial sleep deprivation associated with anaerobic exercise has to be taken into account as a cause of immune alterations (Abedelmalek, et al., 2013). Another example for the sensitivity of hormonal and immune responses to sleep restriction and exercise stimuli is the increase of pro-inflammatory cytokines (Abedelmalek, et al., 2013; Vgontzas et al., 2004), which is associated with unfavourable metabolic profiles (Vgontzas et al., 2004) and inflammatory disease risk. Fullagar et al. (2015) provided evidence in their review for the decrease after 4 h of sleep restriction in mean and peak power during a Wingate anaerobic cycle test in different populations.

The vast array of effects on emotion regulation caused by sleep restriction made it difficult to summarize these effects (Fullagar et al., 2015). Nevertheless, there is evidence reporting lower mood states after sleep restriction, including decreases in vigour, which can increase sleepiness and confusion (Edwards & Waterhouse, 2009; Reilly & Piercy, 1994). Similar, the effect of sleep restriction on memory and recall is also still under discussion. Some authors report that sleep restriction leads to reductions of short-term memory (Waterhouse, Atkinson, Edwards, & Reilly, 2007), whilst others report no effect (Drummond, Anderson, Straus, Vogel, & Perez, 2012). These contrary results could depend on the different kinds of short term memory. For instance, Waterhouse et al. (2007) used a digit span test to measure short term memory, while Drummond et al. (2012) focused on visual working memory. For that reason, such results should be interpreted with caution and the different kinds of short term memory should be taken into account. In this connection, Fullagar et al., (2015) points out that it is questionable whether sleep restriction affects athletes´ motor skill memory, but could potentially affect the recall and understanding of the athletes´ tactical awareness or positioning, which may be important for performance in team-sports.

Over and above that, other studies reported the direct effect of partial sleep deprivation on sport specific performance, as the throwing accuracy and variability of dart players (Edwards & Waterhouse, 2009), the serving accuracy of tennis players (Reyner & Horne, 2013), and cognitive performances as reaction time and attention in the handball goalkeepers, (Jarraya, Jarraya, Chtourou, & Souissi, 2014).

Sleep extension

After mentioning the mainly negative effects of sleep deprivation it is also important to mention the effects of sleep extension on the mechanisms important for athlete´s performance.

In a study by Mah, Mah, Kezirian, and Dement (2011) basketball players were asked to sleep as much as possible for 5 to 7 weeks. As a result they improved the times on 282-foot sprints, as well as the free throw and three-point shooting accuracy, compared to the baseline before the sleep extension. However, due to methodological limitations, the findings should be interpreted with caution, notably the lack of a control group. The same research group also increased the sleep time of swimmers up to 10 h per night for 6-7 weeks, resulting in better 15 m sprint time, reaction time, turn time, and mood (American Academy of Sleep Medicine, 2008)

Despite the effect of sleep deprivation on anaerobe performance remains unclear, it could be assumed that tasks requiring short-term high power output are largely unaffected by sleep deprivation, while aerobic performance seems to decrease after sleep deprivation. In turn, cognitive mechanisms are the most sensitive mechanisms to sleep deprivation and sleep restriction. Taking this into account it could be suggested that sleep has a higher impact on the psychological and cognitive functions and mechanisms of sport performance compared to the physiological ones. Therefore, total and partial sleep deprivation are probably more crucial for sports incorporating a high cognitive reliance, as fine motor movements in the serve accuracy of a tennis player (Reyner & Horne, 2013), rather than sports with gross-motor execution, as snatch, clean and jerk, or front squats of weightlifters (Blumert et al., 2007). Also sleep extension showed some trends about the beneficial effect of additional sleep, but more evidence is needed to substantiate this hypothesis. For that reason one purpose of this study is to test a relaxation-intervention (breathing-technique) for the prevention of athlete´s partial sleep deprivation prior to competition.

Reasons for bad sleep

To ensure that athletes get the required amount and quality of sleep, it is necessary to take a look at the mechanisms influencing sleep. According to the two-process model of sleep regulation by Daan, Beersma and Borbély (1984), humans´ tendency to sleep is determined by two factors. On one hand by the homeostatic factor defining the time passed since the last sleep episode and on the other hand the circadian factor, as the time of the day. More in detail, several aspects can be made responsible for lower sleep quality and quantity. For example, biological cues regulated by light exposure around bedtime are either weakened or ignored for societal reasons, which leads people to delay their bedtime and lowering their sleep quality and quantity (Walch, Cochran, & Forger, 2016).

Besides insomnia as a long term sleep-disturbance, sleep quality and quantity can also be lowered for a short period of time. Such short term sleep disturbances, can be caused by thoughts about forthcoming stressful events, like life-threatening surgeries, or test anxiety (Erlacher, Gebhart, Ehrlenspiel, Blischke, & Schredl, 2012). Also sport competitions can be such stressful events, leading to poor sleep, particularly the night(s) prior to an important competition (Lastella et al., 2014). Subsequently, it was found that over two-thirds of elite athletes in Germany and Australia experienced at least once per year poor sleep quality in the night before competition (Erlacher, Ehrenspiel, et al., 2011; Juliff et al., 2015). Similar to this, Erlacher, Schredel, Ehrlenspiel, and Bosing, (2009) recorded the subjective sleep quality of high-school students before a practice sport examination in track and field, in which the students reported reduced sleep quality, prolonged sleep latency and more nocturnal awakenings on the night before the examination compared to one week or one month before. More in detail, it was found that elite athletes spend significantly less hours on sleep per night before competition (6.5h) than at baseline under training conditions (7.4h) and thus too little according to the recommended 8 hours of sleep per night (Lastella et al., 2015). These results present a good start to measure athlete´s sleep quality and quantity before competitions, but are solely based on subjective instruments such as questionnaires or sleep-diaries. Similar studies with objective measures as polysomnography or actigraphy would shed more light on athlete´s partial sleep deprivation prior to competitions.

External as well as internal causes can be responsible for the low pre competition sleep quality. Athletes reported poor sleep quality and higher frequency of nocturnal awakenings for the night prior to the away game, where they had to sleep in a hotel, compared to the nights prior to home games (Erlacher, Schredl, & Lakus, 2009). The disturbed sleep, which athletes experience in an unfamiliar location, is comparable with the “first-night effect” (poor sleep during the first night in a sleep laboratory), which is well known in sleep research and can be seen as an external cause (Agnew Jr, Webb, & Williams, 1966). Furthermore, the travel schedule and travelling itself, especially over several time zones, may desynchronise the circadian rhythm and lead to reduced or fragmented sleep (Davenne, 2009). This circadian desynchronization is a well-known syndrome of symptoms called “jetlag” manifested by physiological adaptions (Samuels, 2012). Investigating the effect of “jetlag”, Thun, Bjorvatn, Flo, Harris, and Pallesen (2015) reported different results for eastwards and westwards travels on athletic performance, probably because of the interference with other causes, as the above mentioned “first night effect”. Other factors as nutrition may also influence sleep. because valerian, melatonin, tryptophan, high glycaemic index diet before bedtime, and maintenance of a balanced and healthy diet have been found to positively influence sleep, while the consumption of alcohol and caffeine and hyper-hydration may disturb sleep (Halson, 2008). Moreover, some studies also suggest that there are genetic traits which may influence the quality and duration of sleep as well (De Gennaro, et al., 2008; Sehgal & Mignot, 2011). However, according to Lastella et al. (2014), noise, the need to use the bathroom and early event times were the most commonly reported external causes of disrupted sleep before competition.

Besides these external factors, internal factors, as pre-competition anxiety and excitement were reported by a variety of studies to disturb athletes´ sleep quality prior to competition (Erlacher, Schredl, & Lakus, 2009; Lastella et al., 2014; Savis, 1994). Juliff et al. (2015) suggested that the main sleep problem for the athletes was falling asleep (82.1%), and that the most responsible reasons for this were thoughts about the competition (83.5%) and nervousness (43.8%). Also Bird (2013) mentioned in his review, that excessive worry and anxiety related to competitions causes the decrease of sleep quality, probably because of the emotional reactions of the athlete to these psychological states. Nevertheless, all these results are based on subjective measurements, which makes the use of objective measurements via polysomnography or actigraphy necessary to gain more evidence for these findings.

Promoting better sleep

Sleep Hygiene

Different approaches are available for athletes to counteract the internal factors for sleep deprivation and increase the possibility for the optimal amount and quality of sleep. One of the oldest approaches is sleep hygiene, which was first introduced by Paolo Mantegazza in 1864 (Gigli & Valente, 2013). One century later, Peter Hauri made in 1977 an attempt to scientifically establish the concept of sleep hygiene education, referring sleep hygiene to aspects of lifestyle, behaviour and environmental factors that are believed to promote improved sleep quality and quantity (Cummiskeyl et al., 2013; Stepanski & Wyatt, 2003). This can include the elimination of the bedroom clock, the avoidance of, alcohol and nicotine before going to bed, the regulation of the bedtime, the elimination of noise and light in the sleep environment, or the use of relaxation techniques for falling asleep (Stepanski & Wyatt, 2003). Some authors reported improved sleep hygiene (Azevedo et al., 2008; Sousa, Cortez, Araújo, Azevedo, & Macêdo, 2007), and significant changes in sleep duration (Brown, Buboltz Jr, & Soper, 2006) after sleep hygiene and sleep education programs, while others didn´t found any effect (Moseley & Gradisar, 2009).

With these results in mind, Blunden, Chapman, and Rigney, (2012) concluded that sleep education or sleep hygiene programs provide mixed results and do not necessarily neither change sleep behaviour, nor increase sleep quantity or better sleep hygiene.

Psychological Skills Training

Another approach, to counteract the internal factors for sleep deprivation and promote the optimal quality and quantity of sleep, is psychological skills training (PST), which is the most common used approach in sport psychology (Dosil, Cremades, & Rivera, 2014). The main focus of PST is the improvement of athletic performance, which can be achieved through the application of psychological skills learned and developed through PST. The development of psychological skills can also lead to the flow-experience, which is defined as "the state in which people are involved in an activity that nothing else seems to matter" (Csikszentmihalyi, 1990, p.4). Other parts of PST are that athletes' mental weaknesses will be reduced and their mental skills as well as talent will be enhanced and developed. The performance enhancing effect is gained by using different mental skills to enhance ability to cope with problems, which is seen as the most important characteristic of PST (Dosil et al. 2014). These different mental skills can be learned, developed, or changed, by the use of different techniques. However, depending on the uniqueness of every athlete and his issues some techniques might fit better to enhance specific psychological skills than others. The most often mentioned techniques to improve mental skills and reach peak mental performance are goal setting, relaxation skills, visualization/mental rehearsal, self-talk/positive thoughts, and biofeedback techniques (Hardy, Jones, & Gould, 1996; Vealey, 2007).

Internal factors for partial sleep deprivation as pre-competition anxiety, nervousness and worry can be seen as uncontrollable pre-sleep cognitive activity, whose manipulation can change the Sleep Onset Latency-SOL (Ansfield, Wegner & Bowser, 1996). Different techniques have been found as useful in lowering uncontrollable pre-sleep cognitive activity to promote sleep. One technique is imagery, which focus on the creation of experiences in the mind to affect behaviour, thoughts, and emotions (Bhasavanija & Morris, 2014). This is because psychological states as pre-competition anxiety, nervousness and worry, which are negatively affecting sleep, can be addressed by using imagery. For example, athletes can imagine to feel relaxed and calm in the evening before an important competition, to address issues related to anxiety or worry. Harvey and Payne (2002) found that already brief training in the identification and elaboration of a pleasant and relaxing imagery task before going to sleep reduces discomfort and pre-sleep cognitive activity and therefore shorten the SOL. This might reduce the partial sleep deprivation of athletes, because falling asleep is the most common sleep-issue of athletes prior to competition (Juliff et al., 2015).

In the first instance, relaxation techniques have been found as beneficial for promoting sleep. This is because relaxation skills are one of the most often used techniques, to promote the athletes with a strategy to self-regulate their arousal levels, manage their physical energy and decrease anxiety or stress levels (Dosil et al., 2014). Relaxation practises, such as autogenic training (mind to muscle) or Progressive Muscle Relaxation (PMR) (muscle to mind), are assumed as very useful to improve sleep patterns before competition. Already Woolfolk and McNulty (1983) found that PMR and imagery training were beneficial for the prevention of sleep disturbances, but didn´t report any difference between both approaches. Also music-assisted relaxation is seen as an effective support for improving sleep quality (De Niet, Tiemens, Lendemeijer, & Hutschemaekers, 2009).

Compared to other relaxation techniques, focused breathing is a very beneficial technique to achieve the relaxation response before sleep, because of its simplicity, low time consumption and the mindful focus on the task repetition (breathing). This is supported by the difficulty to think about worries and focus on your breathing at the same time. With this in mind Feldman, Greeson, and Senville (2010) tested a breathing technique based on mindfulness and the effect on Repetitive Thoughts (RT), which probably cause sleep deprivation. They reported higher frequency of RT as an effect of mindful breathing, but no difference in negative reactions to RT compared with participants using progressive muscle relaxation and loving-kindness meditation. This might be due to the increased notice and acceptance of thoughts, which are irrelevant for the breathing exercise, besides the increased awareness of physical sensations especially those associated with the process of breathing. Moreover, the frequency of pre-sleep thoughts is perhaps less relevant for falling asleep than the distress associated with pre-sleep cognitive activity (Harvey & Payne, 2002). Through the exclusion of the mindful focus on noticing and accepting other thoughts, this breathing exercise would lose the theoretical mindful foundation where it is built on (Feldman et al., 2010), but probably lead to a lower frequency of RT. From a similar point of view Arch and Craske (2006) found that 15 min of focused breathing leads to more adaptive responding to negative stimuli, compared to people with 15 min of unfocused attention or worry. Focused breathing before going to bed made athletes probably more adaptive to the stimuli of nervousness or pre-competition-anxiety and improve the sleep quality. Besides the psychological benefits also physiological ones exists in connection with focussed or rhythmic breathing on falling asleep. The Respiratory Sinus Arrhythmia (RSA) is one effect, which causes the rise during inhalation and fall during exhalation of the heart rate (Yasuma & Hayano, 2004), and can promote sleep by reducing stress. For example, 6 breaths per minute, including exhales of 6 seconds, can engage the “rest and digest” mechanism (i.e. the parasympathetic nervous system) to slow down the heart rate whereas an inhalation of 4 seconds momentarily stops the slowdown mechanism to speed up again. This fosters higher heart rate variability, and creates a better balance between activation and deactivation of the parasympathetic nervous system, which leads to reduced stress, and flexibility in attention (Strack & Gevirtz, 2011; Thayer, Hansen, & Johnsen, 2010). Based on RSA, Tsai, Kuo, Lee, and Yang (2015) found that slow paced breathing exercises reduces SOL as well as Wake After Sleep Onset (WASO) and increases Self Efficacy (SE), which support the use of breathing relaxation techniques to improve sleep quality. Another benefit of 15 minutes of focussed breathing is the more adaptive response to negative stimuli (Arch, & Craske, 2006). A lower heart rate is also achieved, because breathing at this synchronised pace leads to optimal exchange of oxygen and carbon dioxide gases between the lungs and the blood stream (Yasuma & Hayano, 2004).

Biofeedback based on heart rate variability has been found as a supportive stress coping tool for athletes to modulate their emotions (Paul & Garg, 2012). However, Paul, and Garg (2012) attribute the effects of the heart rate variability biofeedback on stress and anxiety to the used paced breathing technique with around six breaths per minute as part of the biofeedback based. Eventually the breathing technique used in this context of biofeedback is the main cause for the increased athlete´s ability to modulate emotions and reduce stress. Other psychological techniques as Self-talk would probably increase the athletes´ pre-sleep cognitive activity, which is seen as a disadvantage for falling asleep (Coulon et al., 2012). The low evidence for other techniques and the above mentioned benefits of focussed breathing lead to the assumption that focussed breathing as a relaxation technique is probably the most appropriate technique to promote sleep. This is in line with Fletcher and Hanton (2001) who suggested that PST, especially relaxation techniques, could help to promote sleep quality and quantity, by ensuring a clear mind and relaxed state when going to bed.

Despites the existence of all these strategies, 59.1% of team-sport athletes and 32.7% of individual athletes reported to have no specific strategy to overcome poor sleep (Juliff et al., 2015). Although the majority of individual athletes already mentioned relaxation techniques and reading as strategies to overcome and prevent poor sleep, both team sport and individual sport athletes would benefit from sleep education programs. Such programs should include sleep hygiene and focussed or paced breathing, with focus on combatting nervousness and thoughts prior to competition, so that athletes increase their awareness about sleep and their sleep quality and quantity around important competitions.

How to measure sleep

Polysomnography

There is no doubt that polysomnography (PSG) is the "golden standard" for assessing sleep as an objective measure. However, polysomnography might be inconvenient for some populations, as elite athletes before competition, because athletes would be attached to several instruments in laboratory conditions. In addition, the recording of sleep through Polysomnography is very expensive and the first measured night is probably biased by the above mentioned first night effect, so that at least two nights have to be measured in a row (Agnew Jr et al., 1966).

Actigraphy

These issues mentioned for polysomnography made actigraphy more popular in assessing sleep. Several studies demonstrated good validity and reliability of non-dominant-wrist actigraphy compared to PSG (Sadeh, 2011; Slater et al., 2015; Zinkhan et al., 2014). Furthermore, Soric et al. (2013) stated additional advantages of actigraphy, as the possibility of extended monitoring, low invasiveness, unobtrusiveness, and their little effect on usual sleep pattern, which makes the use of actigraphy less costly and more likely to use in subjects´ normal sleep environment. Another benefit for research purposes is the sensitivity of actigraphy-derived sleep parameters to treatment-related changes (Smith et al., 2015). The American Academy of Sleep Medicine (AASM) accepted actigraphy in 1995 as useful, as a research tool for the study of sleep (Thorpy et al., 1995)

Actigraph devices are mostly worn on the non-dominant wrist and different algorithms were used to record three dimensional movements for the determination of a minute-by-minute asleep/wake status. The Cole-kripke algorithm is considered appropriate for older populations, because the algorithm was developed by using individuals at the age of 50.2± 14.7 years (Cole, Kripke, Gruen, Mullaney, & Gillin, 1992). They developed the algorithm with a side by side tests between an experimental actigraph (Webster, Kripke, Messin, Mullaney, & Wyborney, 1982) and the ActiSleep monitor. They scaled the data and developed the algorithm until the sleep score of the Actisleep device matched the sleep score of the experimental actigraph. On the contrary, the Sadeh-algorithm was developed with a younger population between 10 and 25 years of age (Sadeh, Sharkey, & Carskadon, 1994). Here the algorithm was developed by comparing actigraph devices with PSG. This algorithm determines if the subject is asleep/awake by examine the actigraph activity over an 11 minutes sliding window, for each analysed minute.

However, the sleep/wake scoring of actigraphy is based on movements and therefore limits the validity of the estimation of sleep-onset latency (Martin & Hakim, 2011). Another limitation is that until today no standardized manual documenting fundamental technical and scoring practises has been published (Smith, 2015). So differences between actigraph measures can depend on location of the device placement (Zinkhan et al., 2014), and the used algorithm to score sleep/wake (Sadeh, Alster, Urbach, & Lavie, 1989). For that reason such an actigraphy-manual would be essential to become a more widely-use research tool.

Sleep-log

Sleep-logs or Sleep-diaries include questions about the participants sleep behaviour and sleep habits, like nutrition, bed-time, daytime-naps or nocturnal awakenings. These logs are on a self-reported base, and participants have to fill them in on a daily rhythm. This tool allows researchers to get a subjective vision, about different aspects influencing the participants sleep, over a prolonged period. Baker, Maloney, and Driver (1999) stated that sleep-logs provide useful information about the individual´s habits and perception of sleep.

Nevertheless, it is important to mention that subjective reports of sleep might differ from objective measurements, which can lead to misperceptions of sleep parameters (Kawada, 2008). This misperception can be caused by mood and memory biases, as well as personal characteristics (Jackowska, Dockray, Hendrickx, & Steptoe, 2011; Martin & Hakim, 2011). However, studies comparing subjective with objective measurements showed that individuals indeed tend to perceive longer SOL and less awakenings during the night, compared to the more objective Polysomnography (PSG) (Baker et al., 1999), or actigraphy (Kölling, Endler, Ferrauti, Meyer, & Kellmann, 2015).

To detect and manage sleep problems, as accurate as possible, it is important to examine habits and perception of sleep with subjective and objective measures (Myllymäki et al., 2011). This is important because possible misperceptions of sleep states can only be detected by comparing subjective and objective instruments (Tryon, 2004). Similarly, Erlacher et al. (2012) noticed that until now the sleep quality before competitions was never measured with objective measurements.

Aim of the study

To sum up, the literature is lacking objective evidence for partial sleep deprivation prior to important competitions. In addition to that, there is no clear evidence about the influence of interventions as sleep hygiene to prevent sleep deprivation in athletes, especially before competition. Despite the fact that the influence of a relaxation technique combatting nervousness and thoughts prior to competition, has been suggested to prevent the decrease in pre-competition sleep quality and quantity, according to my knowledge nobody tested this suggestion. Also, the missing standardised guidelines for the use of actigraphy as a research tool made it difficult to compare different studies using the same device.

For that reason the aims of this study are three-fold: a) to examine if there is a difference in athletes´ subjective and objective sleep quality and quantity between pre-training and pre-competition nights, b) to evaluate if a relaxation-intervention (breathing-technique) can prevent the decrease in athlete´s pre-competition sleep quality and quantity, and c) to test the advantages and disadvantages of different subjective and objective instruments for the assessment of sleep quality and quantity. According to these three aims the following Hypotheses (H) are designed:

H1.1: There is a difference between training nights and competition nights in subjective and objective sleep quality and quantity.

H2.1: There is a difference in subjective and objective sleep quality and quantity between the experimental group and the control group at the three measurement times, as well as between the three measurement-times for each respective group.

H2.2: There is a difference in the Sleep-hygiene-Index (SHI) and the Pittsburgh Sleep Quality Index (PSQI) between the experimental group and the control group at the two competition-measurements, as well as between the two competition-measurements for each respective group.

H2.3: There is a correlation between the SHI and the PSQI.

H3.1 There is a difference between the SADEH and the COLE-KRIPKE-Algorithm in the objective data.

H3.2: There is a difference between the wrist and the ankle actigraphy in the objective data.

H3.3: There is a difference between the first and the second night of a measurement-night-pair in subjective and objective sleep quality and quantity.

H3.4: There is a correlation of “time to bed” and “overall-stress” with subjective/objective sleep quality.

H3.5: There is a difference between the subjective and the objective sleep quality and quantity.

Methods

Participants

Twenty competitive athletes (7 female; M_{age} = 22.55 years, SD = 4.45) were recruited from different sports (19 soccer, 1 tennis) completing all three measurements. Additionally, 6 competitive athletes (1 female; M_{age} = 28.83, SD = 15.87; 4 basketball, 1 tennis, 1 soccer) completed the first two measurements, and another 18 competitive athletes (0 female; M_{age} = 24.78, SD = 9.01; 11 basketball, 5 soccer, 2 volleyball) completed the first measurement. Competitive athletes participate in an official league or tournament as an individual or as part of a team. All participants were Greek citizen from the region of Thessaly, except for one participant who is a Nigerian citizen, but also lived in the region of Thessaly. Written informed consent was obtained from each participant prior to testing (Appendix A).

Design

In this study a two-group quasi-experimental design was used and included three measurements with two nights each. The literature showed mixed results for gender differences in sleep quality and quantity (Erlacher, Ehrlenspiel, et al., 2011; Leeder, Glaister, Pizzoferro, Dawson, & Pedlar, 2012). However, to prevent any possible gender effect the 20 participants were assigned by gender to the control group (3 female) or the experimental group (4 female). The first measurement took place before a training day, whereas the other two measurements took place before a competition. Although the literature show mixed results for the influence of the female menstruation-cycle on sleep (Romans et al., 2015), we decided to prevent the low and non-significant influence of the premenstrual phase on sleep quality by not measuring the female athletes during the ten days pre menstruation. The experimental group participated in a 13 days relaxation intervention based on a focussed breathing technique, prior to the second competition. The control group was set up on a waiting list and got the same information including results of their sleep after all measurements. The 13 days before the second competition participants had to fill in a manipulation check on a daily base, to check if respectively to the group the focussed breathing technique was used or not. In addition the Greek self-assessment scale based on the Common European Framework of Reference (CEFR) for Languages: Learning, teaching, assessment was used to evaluate the individual's English-language proficiency of the experimental group, to ensure that the participants can understand and follow the instructions during the workshop (Appendix B).

Measurements

Habits and perception of sleep as well as objective sleep parameters were monitored with subjective (sleep-log & questionnaires) and objective measurements (actigraphy) to detect differences in sleep quality and quantity for the respecctive hypotheses (Myllymäki et al., 2011). Two actigraph-devices were worn by the participants at the non-dominant wrist and the non-dominant ankle, at both nights of each measurement. While the devices were handed over to the participants, the participants were informed that the devices record movements and were provided with instructions for tighten and removal of the devices. At both locations the devices were fixed with an elastic band. The measurements took place at the respective sleeping-place and at the respective sleeping time of each athlete. The devices were returned after each measurement to upload the data onto a computer for scoring and analysis. A sleep-log was always handed out with the actigraphs for the respective nights.

Further, measurements include a form of consent, demographic questions, the PSQI and the SHI before and after the intervention.

The conjunction of sleep diaries with actigraphy is supposed to increase the accuracy of actigraphy sleep/wake assessment (Acebo, Sadeh, & Seifer, 2005).

Actigraphy

In this study actigraphy was preferred over polysomnography, because of the above mentioned benefits of actigraphy. Through this we prevent the above mentioned influences of PSG, which could cover up the impact of the focussed breathing intervention. Furthermore, the negative influence of PSG would not be in harmony with the overall goal of this study, to increase the sleep quality and quantity pre competition, and would have made it more difficult to find suitable subjects for this study. Actigraphy recordings were performed using GTX3+ actigraphs (Actigraph, FL, USA), a small (4.6cm x 3.3cm x 1.5cm), lightweight (19 grams) triaxial solid state accelerometer based activity monitor. The GTX3+ actigraphs showed 90% sensivity (the proportion of epochs correctly scored by actigraphy as sleep) and 84% accuracy (the proportion of all epochs correctly scored as wake or sleep) compared to PSG (Slater et al., 2015). Specifity (the proportion of epochs correctly scored as wake) was only 46% compared to PSG, but achieved the recommended minimum of 40% (Tryon, 2004).

Sleep-log

The sleep-log was based on the Consensus Sleep Diary (CSD) by Carney et al. (2012). The advantage of this sleep-log is that the use of both, insomnia experts and potential users were used for the sleep-log development process.

The used sleep-log adapted from the CSD included two parts, so that the participants had to complete some items in the morning and other items in the evening before going to bed. The participants were asked about their napping and drinking (alcohol & caffeinated drinks) habits (amount and time of the last drink), as well as details about sleep medication the day before the respective measured night. Moreover, the participants were asked about the time they went to bed (hh:mm), the time they went to sleep (hh:mm), SOL (min), WASO (min), awakenings (number), Final Awakening (FA) (hh:mm), the time they tried to sleep after the final awakening (TTS) (min), the time they woke up earlier than planned (min), and the time they got out of the bed (hh:mm). The total sleep time was calculated by subtracting the total time of awakenings from the time between "going to sleep" and "final awakening".

In addition, the sleep-log included five questions which the participants had to rate on a five-point scale about the perceived sleep quality (very poor, poor, fair, good, very good), perceived freshness the next morning, perceived influence of the actigraph-device on sleep, notice of the actigraph-device while sleeping, and overall stress (all four: not at all, slightly, somewhat, much, very much). The sleep-log also included demographic questions about name, gender, age, education, main-sport, and sport-experience (Appendix C).

To be sure that both measured competition have the same importance for the athletes, the sleep log for the measurements pre competition, included the importance of the upcoming match on a five-point scale (1= not at all, 2= slightly, 3= somewhat, 4= much, 5= very much) (Appendix D). The sleep-log was formulated and handed out in English and Greek.

Manipulation-check

The manipulation-check for the control group included five questions about the use of any technique for falling asleep or to relax (number & time), and if they perceived these techniques, as useful (Appendix E). The manipulation-check for the experimental group included five questions, about the use of the focussed breathing technique for falling asleep or to relax (number, & time), and if the controlled breathing technique was perceived as useful (Appendix F). Both manipulation checks were handed out in English and Greek.

Pittsburgh sleep quality index

The Pittsburgh Sleep Quality Index (PSQI) is a self-report measure of sleep quality, (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI includes 18 items, indicating the amount of sleep and rating the extent to which various factors interfered sleep, where 13 items were rated on a four-point Likert-type scale (0 = not during the past month, 1 = less than once a week, 2 = one or twice a week, 3 = three or more times a week) and 1 item on a four-point Likert-type scale (0 = very good, 1 = fairly good, 2 = fairy bad, 3 = very bad). The items yield scores on seven subscales, so that each subscale produce a score from 0 to 3. These scores are summed up to a global score between 0 and 21, with higher total scores indicating poorer sleep quality. The calculated global score of the PSQI is a practical approach for a researcher looking to quantify a population's sleep quality, and to discriminate “good” and “poor” sleepers (Mollayeva et al., 2016). The translation of the PSQI into over 56 languages underlines, that the PSQI is currently the only standardized clinical instrument that covers a broad range of indicators relevant to sleep quality (Takács et al., 2016). In this study we used the Greek version of the PSQI (GR-PSQI), which was validated with a Chronbach’s alpha of 0.76 for the global GR-PSQI (Kotronoulas, Papadopoulou, Papapetrou, & Patiraki, 2011).

Sleep Hygiene Index

The Sleep Hygiene Index (SHI) self-administered index was developed as well as validated (α = 0.66) by Mastin, Bryson, and Corwyn (2006) and intends to assess the practise of sleep hygiene behaviour. The 13 items measure behaviours and environmental variables, like caffeine intake before bedtime, thought to cause or lead to relatively poor sleep quality rather than measuring the outcomes. The items were derived from the diagnostic criteria for inadequate sleep hygiene in the International Classification of Sleep Disorders. Individuals using this scale were asked to indicate how frequently they engage in specific behaviours on a five-point scale (always, frequently, sometimes, rarely, never). The item scores were summed up to provide a global score of sleep hygiene. Hereby, higher scores were indicated with more maladaptive sleep hygiene.

Intervention

The intervention included a workshop (~90 minutes) which was separated in two parts. In the first part, participants were educated shortly about sleep and the importance of sleep for athletes and to which extend athletic performance can be affected via sleep deprivation. The participants were also introduced to the topic and the purpose of the study.

In the second part of the workshop the participants were taught a breathing technique for relaxation purposes before going to sleep. The aim of the focused breathing induction was to direct the attention and awareness to the breathing and to use diaphragmatic breathing for 6 breaths per minute (4 sec. inhalation; 6 sec. exhalation). If necessary, the participants were encouraged to redefine this rhythm, so that they perceive their breathing as comfortable, as long as they still use longer exhalations than inhalations and breathe rhythmically to gain the different benefits on HVR and HR leading to reduced stress, flexibility in attention (Strack & Gevirtz, 2011; Thayer, Hansen, & Johnsen, 2010; Yasuma & Hayano, 2004), a more adaptive response to negative stimuli (Arch, & Craske, 2006) and the optimal exchange of oxygen and carbon dioxide gases (Yasuma & Hayano, 2004). The athletes were encouraged to use this breathing technique by themselves for 13 successive nights in their normal sleeping environment, before the second competition. Hereby they had to use the focused-breathing technique for 10 minutes before going to sleep while lying in bed.

Data-Analysis

Wrist and ankle actigraphy data were downloaded and analysed using the ActiLife software (Actigraph 2012, ActiLife 6). Data were digitalized by a 12-bit-analog to digital converter at 60 Hertz (Hz). The time of “time to go to sleep” and “final awakening” were taken for the scoring of the actigraphy data from the sleep-log. Actigraphy data were scored in one-minute epochs as awake or asleep according to Sadeh´s and Cole-Kripke´s algorithm (Cole et al., 1992; Sadeh et al., 1994). Data analyses were performed using Statistical Package for the Social Science (SPSS v20.0). For several reasons the data, except for the H3.1, was only analysed with the Sadeh-algorithm. On one hand the age-range of the population of this study fit better to the age-range of the population used in the Sadeh-algorithm-development, compared to the Cole-Kripke-algorithm development. On the other hand, the used GT3X-Actigraphs showed good agreement with PSG by using Sadeh´s algorithm (Slater et al., 2015).

Furthermore, except for the H3.2, the scored and analysed data was collected by wrist-actigraphy, because the non-dominant-wrist is the most commonly used placement for actigraphy to measure sleep parameters (Slater et al., 2015). A single trained scientist scored and analysed all actigraphy recordings.

The primary objective sleep variables collected were: total sleep time (TST: minutes of total sleep between “time to go to sleep” and “final awakening”), sleep efficiency (SE: minutes of total sleep time divided by minutes available for sleep between “time to go to sleep” and “final awakening”, then multiplied by 100 to obtain a percentage); sleep onset latency (SOL: number of minutes from “time to go to sleep” to the first epoch scored as sleep) and wake after sleep onset (WASO: number of minutes awake between first epoch scored as sleep and “final awakening”). The most popular subjective sleep variables were TST, SOL, WASO, sleep quality (SQ; the perceived sleep quality on a 5 point scale), time to sleep (TTS; the time of the day the athlete went to sleep), earlier final awakening (EFA; number of minutes awake until the planned time of awakening) and freshness (FR: the perceived freshness at the next morning on a 5 point scale).

The respective measurements of TST, SE, SOL, WASO, SQ, TTS, EFA, and FR derived from actigraphy and sleep logs the last night before competition were compared for H1.1, H3.1, H3.2, H3.3, and H3.5 by using paired sample t-tests. The hypotheses H2.1, and H2.2 were tested via two-way repeated measures ANOVAs with one repeated factor. Also Pearson-correlation was used to test the hypotheses H2.3, and H3.4.

Results

In order to examine the hypothesis, for the analysis of the control and experimental group (n = 20), that both groups do not differ in all sleep parameters at baseline we used the independent t-test. The results showed statistically significant differences at baseline between both groups in subjective SOL t (19) = -2.14, $p <$ .05 and SQ t (19) = .08, $p <$ .05. A One-way Analysis of Covariance (ANCOVA) was conducted to determine a statistically significant difference between the control and experimental group on the subjective SOL at the second measurement controlling for the subjective SOL at baseline. There is no significant effect of group on subjective SOL at the second measurement after controlling for the subjective SOL at baseline, F (1,17) = 4.33, p = .05. Also, a One-way ANCOVA was conducted to determine a statistically significant difference between the control and experimental group on the SQ at the second measurement controlling for the subjective SQ at baseline. There is a significant effect of group on subjective SOL at the second measurement after controlling for the subjective SOL at baseline, F (1,17) = 6.37, $p <$ .05.

To compare the importance of the competition between both measurements we used paired samples t-test in order to examine our hypothesis, that there is no difference between the first competition and the second competition in measuring the match-importance for the control and the experimental group. The results showed statistically non-significant difference between the first competition and the second competition in match importance for the experimental group, $t\ (9) = .25$, $p = .81$, and the control group, $t\ (9) = 1.50$, $p = .17$.

In order to examine the hypothesis that there is no difference in importance of the competition between the control group and the experimental group at the first competition, we used independent t-tests. The results showed a statistically non-significant difference at the first measurement, $t\ (18) = 1.55$, $p = .14$, as well as at the second measurement, $t\ (18) = 1.71$, $p = .10$.

A paired sample t-test was conducted to compare subjective as well as objective sleep parameters in the night before training and the night before competition conditions. There was no significant difference for all parameters in the night before training and the night before competition conditions (Table 1).

The participants in the experimental group perceived in average themselves as independent users of the English language according to the B1-level ($M = 3.47$, $SD = 1.49$) based on the CEFR. Also the participants perceived in average the first competition ($M = 4.2$, $SD = 0.89$) and the second competition ($M = 3.95$, $SD = 1.23$) as “very important”.

Furthermore, the participants perceived, that the actigraphs in average have a “slightly” ($M = 1.62$, $SD = 0.78$) influence on their sleep. actigraphs were in average also “slightly” ($M = 1.75$, $SD = 0.95$) noticed by the participants during the night.

The manipulation check indicated that no athlete of the control group used the focussed breathing technique for falling asleep or relaxation purposes. On the other hand did the experimental group used the focussed breathing technique in average at 9.7 nights (*SD* = 2.63) for 5.72 minutes (*SD* = 5.40). They perceived the focussed breathing technique with an average score of 4.04 (*SD* = 0.71) as “very useful”. Furthermore made the breathing technique it “very easy” for the athletes to relax (*M* = 3.84, *SD* = 0.62) and to fall asleep (*M* = 3.93, *SD* = 0.67).

Table 1

Results of paired samples t-test and Descriptive Statistics for subjective and objective sleep parameters by sleep-condition.

	Training		Competition						
Outcome	M	SD	M	SD	n	95% CI	r	T	df
Subjective									
TTS	85.23	97.59	101.08	71.28	26	[-48.67, 16.97]	.58**	-.99	25
SOL	13.64	9.27	15.35	13.22	26	[-6.61, 3.2]	.46*	-.72	25
WASO	6.06	7.50	11.04	20.64	26	[-12.7, 2.74]	.38	-1.33	25
FA	553.78	111.73	589.08	111.4	26	[-92.92, 22.3]	.18	-1.26	25
EFA	6.92	14.29	2.89	8.51	26	[-2.89, 10.97]	-.07	1.2	25
TST	464.79	82.52	467.87	97.32	26	[-58.99, 52,83]	-.18	-.11	25
SQ	3.58	.95	3.46	.95	26	[-.36, .59]	.23	.5	25
FR	3.38	.82	3.46	.93	24	[-.51, .35]	.33	-.4	25
Objective									
SOL	1.58	2.58	2	4.05	26	[-2.11, 1.26]	.27	-.52	25
TST	398.08	73.67	413.19	93.83	26	[-63.28, 33.05]	.01	-.646	25
WASO	68.89	39.02	63.58	28.85	26	[-9.4, 20.02]	.46*	.74	25
SE	85.04	7.47	85.95	6.01	26	[-3.46, 1.64]	.58**	-.73	25

Notes: TTS = the time of the day when the athletes went to sleep; SOL = Sleep onset latency; WASO = Wake after sleep onset; FA = time of the day when the athletes had their final awakening; EFA = minutes the final awake was earlier than planned; TST = Total sleep time; SQ = Sleep quality; FR = perceived freshness the next day; SE = Sleep efficacy.
* $p < .05$, ** $p < .01$.

Table2

Results of a two-way repeated measures ANOVA to examine differences in sleep parameters between measurement-times and within groups (n = 20).

	Training		Competition1		Competition 2		Group x time		
Outcome	Experimental	Control	Experimental	Control	Experimental	Control	*F* (2.36)	*p*	*ηp²*
Subjective									
TTS	71.1± 97.54	71.6± 76.07	65.3± 33.03	122± 90.41	82.5± 77.4	110.8± 101.89	1.36	.27	.07
SOL	7.85± 6.33	16± 10.22	12.25± 12.2	16.4± 8.46	21.2± 21.76	15.1± 16.48	2.25[a]	.14	.11
WASO	5.9± 5.89	8.95± 9.81	13.05± 12.47	14.2± 30.98	15.1± 14.2	6.55± 6.92	1.11[a]	.32	.06
FA	569.6± 74.99	535± 126.8	567.7± 88.03	561± 122.11	593.5± 81.92	540.3± 84.08	.31	.73	.02
EFA	5.5± 10.12	6.5± 11.07	3± 9.49	8.5± 18.86	13± 19.47	13.5± 15.64	.19	.83	.01
TST	496.6± 45.4	460.45± 109.12	489.35± 76.65	425.3± 106.12	489.9± 60.36	450.8± 127.09	.17	.85	.01
SQ	4.1± .57	3.2± 1.14	3.7± .68	3± .94	3.9± .74	3.1± 1.1	.1	.91	.01
FR[b]	3.56±.53	3.3± 1.06	3.67± 1	3.1± .74	3.44± .88	3.3± .95	.4	.68	.02
Objective									
SOL	2.5± 3.31	1± 2.11	4.5± 5.72	1± 1.76	3.9± 4.93	1.9± 3.38	.53	.59	.03
TST	424.5± 48.18	391.6± 86.27	424.1± 66.02	383.6± 106.49	429.85± 57.53	405± 120.56	.06	.95	.01
WASO	75.5± 44.79	70.8± 38.01	73.8± 32.32	54.9± 24.37	79.2± 45.69	52.6± 15.86	.91	.41	.05
SE	84.67± 8.13	84.69± 7.05	84.47± 5.23	86.65± 5.82	83.91± 7.92	87.42± 5.18	.69	.51	.04

Notes: TTS = the time of the day when the athletes went to sleep; SOL = Sleep onset latency; WASO = Wake after sleep onset; FA = time of the day when the athletes had their final awakening; EFA = minutes the final awake was earlier than planned; TST = Total sleep time; SQ = Sleep quality; FR = perceived freshness the next day; SE = Sleep efficacy.
[a] = Greenhous-Geisser corrected, [b] = experimental group (n = 9).

Taken the intervention and the 3rd measurement into account a two-way repeated measures ANOVA was conducted to examine differences in subjective TTS, SOL, WASO, FA, EFA, TST, SQ, SE and FR as well as objective SOL, TST, WASO, and SE before training, the first competitions, and the second competition, between the control and experimental group. The results did not show any significant time or interaction effects (Table 2). The means and standard deviations of subjective and objective TST, WASO, SOL as well as sleep efficacy pre and post intervention are visual represented in the tables G1, G2, G3, and G4.

With view on the relaxation-intervention we conducted a 2x2 ANOVA to determine the differences in the SHI between the control and the experimental group before and after the breathing intervention. The results revealed non-significant group effect, F (1,36) = .05, p = .82, time effect, F (1,36) = .01, p = .98, and interaction effect, F (1,36) = .15, p = .70.

Additionally, we conducted a 2x2 ANOVA to determine the differences in Pittsburgh Sleep Quality Index between the control and the experimental group before and after the breathing intervention. The results showed significant main effect for groups F (1,36) = 6.01, $p < .05$, non-significant effect for time, F (1,36) = .21, p = .65, and non-significant interaction effect, F (1,36) = .21, p = .65. The examination of the means showed that the control group had a higher scores than the experimental group in the PSQI.

Also this study examined the relationship between the scores of the SHI with the scores of the PSQI. Scores of the SHI did not correlate with scores of the PSQI (r = -.16, p = .33).

Descriptive statistics of all measured nights include also participants who didn´t complete all measurements (Table 3).

Table 3

Descriptive statistics for all measured nights (N = 174)

	Minimum	Maximum	*M*	*SD*
Subjective				
TTS	22:05	05:45	01:20	01:36
FA	04:15	14:45	09:15	01:00
SOL	0	100	14.45	14.03
TST	210	661	464.13	86.95
WASO	0	100	8,35	12,14
Influence of the actigraph	1	5	1.72	.84
Notice of the actigraph	1	5	1.87	1.03
Objective				
SOL	0	60	3.69	7.5
TST	160	582	405.62	83.27
WASO	0	249	65.54	36.41
SE	44	100	85.33	7.55

Note. TTS = the time of the day when the athletes went to sleep; SOL = Sleep onset latency; WASO = Wake after sleep onset; FA = time of the day when the athletes had their final awakening; EFA = minutes the final awake was earlier than planned; TST = Total sleep time; SQ = Sleep quality; FR = perceived freshness the next day; SE = Sleep efficacy.

For the methodological aspects we used paired samples t-tests in order to examine our hypothesis, that there is no difference between the Sadeh-algorithm and the Cole-Kripke-algorithm in measuring SOL, TST, WASO, and SE. The results showed statistically significant difference between the Sadeh-algorithm and the Cole-Kripke-algorithm in SOL, t (173) = 3.57, p < .01, TST, t (173) = -16,57, p < .01, WASO, t (173) = 16.48, p < .01, and SE, t (173) = -18.40, p < .01. The SOL was longer detected by the Sadeh-algorithm (*M* = 3.69, *SD* = 7.48) than with the Cole-Kripke-algorithm (*M* = 2.16, *SD* = 4.21). The TST was shorter detected by the Sadeh-algorithm (*M* = 405.62, *SD* = 83.27) than with the Cole-Kripke-algorithm (*M* = 428.97, *SD* = 85.03). The WASO was longer detected by the Sadeh-algorithm

(*M* = 65.54, *SD* = 36.41) than with the Cole-Kripke-algorithm (*M* = 43.28, *SD* = 26.82). The SE was lower detected by the Sadeh-algorithm (*M* = 85.33, *SD* = 7.55) than with the Cole-Kripke-algorithm (*M* = 90.32, *SD* = 5.81).

We used paired samples t-test in order to examine our hypothesis, that there is no difference between wrist actigraphy and ankle actigraphy in measuring SOL, TST, WASO and SE. The results showed statistically significant difference between wrist actigraphy and ankle actigraphy in SOL, t (173) = 4.00, $p < .01$, TST, t (173) = -20.26, $p < .01$, WASO, t (173) = 21.12, $p < .01$, and SE, t (173) = -22.80, $p < .01$. The SOL was longer measured by wrist actigraphy (*M* = 3.69, *SD* = 7.48) than by ankle actigraphy (*M* = 1.82, *SD* = 3.80). The TST was shorter measured by wrist actigraphy (*M* = 405.62, *SD* = 83.27) than by ankle actigraphy (*M* = 447.48, *SD* = 85.12). The WASO was longer measured by wrist actigraphy (*M* = 65.54, *SD* = 36.41) than by ankle actigraphy (*M* = 24.62, *SD* = 21.60). The SE was lower measured by wrist actigraphy (*M* = 85.33, *SD* = 7.55) than by ankle actigraphy (*M* = 94.42, *SD* = 4.70).

Moreover, we used paired samples t-test in order to examine our hypothesis, that there is no difference between the first and second night of the baseline measurement in determining subjective SOL, subjective WASO, subjective TST, subjective earlier time, subjective SQ, subjective FR, objective SOL, objective TST, objective WASO, and objective SE. The results showed statistically significant difference between the first and the second night in subjective WASO, t (42) = 2.23, $p < .05$, and objective SOL, t (42) = 2.30, $p < .05$, whereas there was non-significant difference for subjective SOL ($p = .19$), subjective TST ($p = .99$), subjective earlier time ($p = .91$), subjective SQ ($p = .16$), subjective FR ($p = .06$), objective TST ($p = .60$), objective WASO ($p = .58$), objective SE ($p = .09$). The subjective WASO was longer in the first night (*M* = 7.69, *SD* = 11.18) than in the second night (*M* =

4.94, *SD* = 6.80). The objective SOL was longer in the first night (*M* = 6.23, *SD* = 11.34) than in the second night (*M* = 2.19, *SD* = 3.81).

Table 4

Bivariate correlations between perceived stress and subjective as well as objective sleep variables (N =86)

		1	2	3	4	5	6	7	8	9	10
1.	Subj. TTS										
2.	Subj. SOL	,312**									
3.	Subj. WASO	-,162	,022								
4.	Subj. EFA	,235*	-,033	,105							
5.	Subj. TST	-,225*	-,308**	,159	,105						
6.	Subj. SQ	-,166	-,329**	-,220*	-,102	,185					
7.	Subj. FR	-,268*	-,319**	-,113	-,085	,082	,693**				
8.	Obj. SOL	,016	-,044	-,124	-,107	,021	,018	-,124			
9.	Obj. TST	-,261*	-,221*	,029	-,029	,319**	,257*	,085	-,197		
10.	Obj. WASO	-,080	,146	,139	-,010	,238*	,035	,021	-,156	,022	
11.	Obj. SE	-,032	-,218*	-,100	,002	-,101	,064	,028	-,172	,362**	-,875**

Notes: Subj. = Subjective, Obj. = Objective, TTS = the time of the day when the athletes went to sleep; SOL = Sleep onset latency; WASO = Wake after sleep onset; FA = time of the day when the athletes had their final awakening; EFA = minutes the final awake was earlier than planned; TST = Total sleep time; SQ = Sleep quality; FR = perceived freshness the next day; SE = Sleep efficacy.
* $p < .05$ (two-tailed), ** $p < .01$ (two tailed)

Also, this study examined the relationship of the time to sleep and overall stress with the subjective and objective sleep parameters. Based on the result of the study, time to sleep and overall stress are weak to moderate related to some subjective and objective sleep parameters (Table 4).

We used paired samples t-test with all measured nights (n = 174) in order to examine the hypothesis, that there is no difference between subjective and objective SOL, TST, WASO and number of awakenings. The result showed statistically significant difference between the subjective an objective SOL, t (173) = 8.79, p < .001, WASO, t (173) = -20.60, p < .001, TST, t (183) = 3.05, p < .01, and number of awakenings, t (173) = -29.49, p < .001. The SOL was longer measured by subjective instruments (M = 14.45, SD = 14.04) than by objective instruments (M = 3.69, SD = 7.48). The WASO was shorter measured by subjective instruments (M = 8.35, SD = 12.14) than by objective instruments (M = 65.54, SD = 36.41). The TST was longer measured by subjective instruments (M = 434.55, SD = 142.13) than by objective instruments (M = 405.62, SD = 83.27). The number of awakenings was lower measured by subjective instruments (M = 1.90, SD = 1.89) than by objective instruments (M = 21.83, SD = 8.91).

Discussion

All tested prerequisite for the analysis were met. The participants of the experimental group perceived themselves as independent users of the English-language (B1-level, CEFR), so that it can be assumed that they understood and followed the instructions during the workshops. Furthermore, the participants perceived in average both competitions as “very important”, so that these competitions are more likely events which lead to the decrease in pre competition sleep quality and quantity (Erlacher, Ehrenspiel et al., 2011; Lastella et al., 2014). Furthermore, it can be expected that the actigraphs had no influence on the measured sleep parameters, because the participants noticed the actigraph devices only “slightly” during the night and perceived the actigraph devices as only “slightly” influential on their sleep. The implementation of the breathing technique for in average of 5.72 minutes at 9.7 nights by the experimental group and no use of any relaxation-technique by the control group provide the necessary prerequisites to test the effect of the breathing intervention on the athletes´ sleep quality and quantity, as well as their sleep hygiene.

The first of our three objectives of the present study was to examine the difference in sleep quality and quantity between a night before training and a night before competition conditions. In contrast to our expected hypotheses and the previous literature we couldn´t confirm the decrease of subjective as well as objective sleep quality and quantity prior to a competition compared to a night prior to training. Previous studies who detected that elite athletes experience at least once per year poor sleep quality prior to competitions, were based on subjective measurements, which leaves the door open for possible misperceptions of the athletes (Erlacher, Ehrenspiel, et al., 2011; Juliff et al., 2015). However, the subjective sleep-logs in our study couldn´t duplicate these results. This may be owed by the low number of participants. This is because also 7% of athletes reported that they sleep better one night prior to competition than usual (Lastella et al., 2014). Therefore, it could be that our sample includes by chance more pre-competition-good sleepers than expected compared to the overall population. Another possible reason is that previous studies examined lower sleep quality and quantity in semi-professional (Erlacher, Schredl, & Lakus, 2009) or elite athletes (Juliff et al., 2015; Lastella, Roach, Halson, Martin, et al., 2015), whereas our sample consists competitive but not elite athletes, so that the importance of the upcoming competition may be higher in professional athletes and therefore elite athletes are more likely to perceive disturbed sleep before competitions. Another aspect is that studies, who detected lower sleep quality prior to competitions, didn´t state if poor sleep was experienced before away or home games (Erlacher, Ehrenspiel, et al., 2011; Juliff et al., 2015). According to Erlacher, Schredl, and Lakus, (2009) it is more likely to experience poor sleep quality and quantity in the night prior to an away game, compared to the night prior to a home game. We measured sleep only before home games, which might be another explanation for detecting no significant difference in sleep quality and quantity between nights before training and a nights before competition conditions. Furthermore previous studies (Erlacher, Ehrenspiel, et al., 2011; Juliff et al., 2015) mentioned poor sleep just once per year prior to competitions, which is in the study by Erlacher, Ehrenspiel et al. (2011) only 5.62 % of all competitive events. Our sample included mostly team-sports, so that our participants competed in average over 20 times per year. This may lower the importance of the competition, and therefore the effect on athletes´ sleep quality and quantity. Another aspect may be, that we measured by chance the wrong competitions, if sleep-disturbances are mostly perceived in only 5.62 % of all competitive events.

Contrary to other studies we couldn´t find a significant effect on earlier time to sleep on the night prior to competitions (Lastella et al., 2014, Romyn, Robey, Dimmock, Halson, & Peeling, 2015), however we noticed a trend towards later times of going to sleep (01:25 vs. 01:41). An explanation may be that our sample included non-professional athletes, so that participants had to work during the week and therefore went earlier to sleep prior to training days compared to competitions, which took place at the weekend and the participants didn´t have to work the next day. For non-professional athletes the job is probably more important than a competition, which leads to earlier times to sleep at baseline.

The second objective of this study was to investigate the effect of a relaxation-technique, based on focussed breathing, on the pre-competition sleep quality and quantity. As expected we found no difference in subjective and objective sleep parameters and in scores of the PSQI and SHI between the measurements at baseline, pre and post intervention for the control group. Surprisingly, the results presented also no differences for the experimental group, although the manipulation-check showed that participants in the experimental group perceived the focussed breathing technique as useful.

Whereas, other training protocols on sports performance used in research, recommend 20-minute breathing sessions for 10 days (Paul & Garg, 2012) the experimental group in this study used the breathing technique for 9.7 nights (*SD* = 2.63) and 5.72 minutes (*SD* = 5.40). The short implementation-time may be label our breathing-intervention as ineffective. Although Thun et al. (2015) noticed that most of the studies investigating sleep deprivation had fewer than 20 subjects, the small sample-size may be another reason for the missing expected effects of the breathing intervention. This may be because sleep architecture, quality and quantity varies drastically across individuals (Klerman & Dijk, 2005), which includes athletes, so that the spreading of the sleep parameters is too big to detect the effect caused by the intervention.

Moreover, the assumption that knowledge about sleep does not necessarily change sleep behaviour, like sleep duration or sleep hygiene (Blunden et al., 2012), may be the reason why our assumption to find a change over time in SHI and PSQI was not confirmed. Motivation, readiness to change, content, time allocation or methodological underpinnings, are some potential reasons discussed in this context.

In addition the requirements for athletes´ sleep are also influenced by several other factors such as, training volume, training intensity, timetable, psychological stress of training and combining training with life activities (Leeder et al., 2012). For that reason, the effect of our breathing intervention is probably too small to make a difference, which can be noticed within the noise of all the other influences. In connection to this, our results showed that higher overall stress, is related to shorter objective TST.

When taken all measurements of all measured participants into account, the total sleep time measured with wrist-actigraphy and scored by the Sadeh-algorithm was in average 6.76 hours per night. This is in line with a previous study combining subjective and objective measures, who showed that Australian athletes went to bed at 22:59 ± 1.3, woke up at 07:15 ± 1.2 and obtained 6.8 ± 1.1 hours of sleep per night (Lastella, Roach, Halson, & Sargent, 2015). Our results also agree with the subjective data by Venter (2012) who reported an average sleep duration of 6-8 hours per night for 890 elite athletes. Contrary to Lastella, Roach, Halson & Sargent (2015), our athletes went much later to bed (*M* = 01:20, *SD* = 1.4). Nevertheless, these results are below the recommended 8 hours of sleep (Natale et al., 2009), and not even close to the suggested 10-12 hours of sleep per night for elite athletes (Scott, 2002). The short sleep duration in our study could be explained by the day time the athletes went to sleep, because as later in the night the athletes went to sleep, as longer was their SOL, and as earlier the athletes woke up than planned, which resulted in shorter perceived and objective TST. Similar results were found by Walch et al. (2016) who assumed, that biological cues around bedtime are either weakened or ignored for social reasons and lead in this case the athletes to delay their bedtime and shorten their total sleep time. Our sample was collected in Greece, so that the Greek culture in connection with the Mediterranean climate, including day-time naps, could be one explanation for the delayed bedtime. Furthermore the short TST could be partially caused by the actual financial crisis in Greece (Nena et al., 2014)

Last but not least, this study also tested the advantages and disadvantages of different subjective and objective instruments for sleep-assessment. From this methodological point of view the results show that the Sadeh-algorithm detect longer SOL, shorter TST, longer WASO and lower SE than with the Cole-Kripke algorithm. The Sadeh-algorithm can therefore be seen as more likely to score minutes as “awake” than “asleep”, compared to the Cole-Kripke-algorithm. Similar Kripke et al. (2010) mentioned that different algorithms could perform differently on different subject groups. The difference between our algorithms, is probably caused be the different development mechanism of the algorithms and the different populations used in the algorithm-development process. For example the sample for the development of the Sadeh-algorithm was with 10 to 25 years of age relative young, compared to the sample used for the development of the Cole-Kripke-algorithm (*M* = 50.2 years of age, *SD* = 14.7). This findings should be taken into account when comparing studies with different algorithms. However, it can´t be concluded if the Sadeh-algorithm is better for measuring objective sleep parameters than the Cole-Kripke-algorithm, so that both should be checked by comparing them with PSG in different populations.

For most sleep parameters no difference could be found between the first night and the second night of a measurement night pair, except perceived WASO (7.6 vs.4.9.min.), and objective SOL (6.2 vs 2.2 min.), which were significant longer in the first nights compared to the second nights. Actigraphy is known for difficulties in measuring SOL (Martin & Hakim, 2011) and the perceived WASO could be explained by the big stray bullet, because all other sleep-parameters show no difference. All in all, this finding makes it more likely that the first night effect (Agnew Jr, et al., 1966), doesn´t exists by using actigraphy. Similar, Soric et al. (2013) noticed that actigraphy has little effects on the usual sleep pattern, because it is a small 19 grams wrist-worn-lightweight tool, compared to the attachments to several instruments during PSG. Another factor for the missing first night effect could be the athletes slept in their normal sleep environment instead of in a laboratory setting. Therefore also the first night of a measurement can be used by future studies for research purposes. Another possibility would be to collect only one night instead of two or more, which makes actigraphy as an instrument to assess sleep parameters more flexible and less time-consuming.

Consistent with previous research our subjective reports deviate from the objective measures (Kawada, 2008). This can be explained by the mood and memory biases, or personal characteristics of the athletes (Jackowska et al., 2011). Our results agree with previous findings (Kölling, et al., 2015; Lockley, Skene, & Arendt, 1999) and show that participants perceived longer SOL and could recall less night-time awakenings than measured by actigraphy. In contrast to Kawada (2008) and Lockley et al. (1999), but in line with Mah et al. (2011) we found that our participants perceive longer TST than measured by actigraphy. Probably some awakenings were too short to be recognized during the night or are not memorized and therefore can´t be recalled the next day, which lead to less remembered periods awake than measured by actigraphy. Besides the limitations of subjective sleep assessment, also actigraphy has some boundaries. For example if subjects who are awake but lie in bed without movments, then minutes can be classified incorrectly as being asleep, because sleep scoring with actigraphy is inferred from the absence of movement (Martin & Hakim, 2011).

Concluding both sleep-log and actigraphy are biased toward overestimating periods as asleep. Furthermore, SOL is considered as a gradual process rather than one moment, which is another reason for the difference between subjective and objective SOL (Ogilvie, 2001). The point that SOL takes place in the grey-zone between awake and asleep, makes it difficult to measure SOL correctly, so that individuals' perception of time awake differs from the objective measurements. We assume that this depends on the movement-suppression when athletes try to fall asleep. It is likely that people lie in bed and suppress movements to promote falling asleep, which can be scored by actigraphy incorrectly as asleep. The suppression of movement is more likely to observe during SOL compared to awakenings during the night, because individuals are perhaps not aware of short nightly awakenings, and are no so cognitive active, so that there is no need for movement-suppression to promote sleep.

As Kölling et al. (2015) already mentioned we agree that discrepancies between subjective and objective sleep parameters should be expected, because they are sensitive to different phases of the sleep onset process. However, Acebo, et al. (2005) recommended to use both methods at the same time, because the conjunction of sleep-diaries with actigraphy increases the accuracy of actigraphy sleep/wake assessment. Taken these aspects into account both methods can be applied as useful tools for monitoring sleep in sport. Nevertheless, after using actigraphy for over 35 years for research purposes, a standardized manual documenting fundamental technical and scoring practise is needed to prevent misinterpretations and promote the comparison of different studies with the same instruments.

All in all, the results of this study should be treated with caution. This is because there are so many other influences on the athletes´ sleep, which makes it difficult to always measure the respective focused effect. This can also be seen at the predominantly small and medium effect sizes for the results of the intervention-analysis. For example the subjective TST (p = .73, ηp^2 = .018; p = .85, ηp^2 = .009) as well as the objective TST (p = .84, ηp^2 = .010; p = .95, ηp^2 = .003) showed only small effect sizes for time and interaction effects. Also the overall individual variation between athletes leads probably to a higher standard deviation (SD) for the different sleep parameters (Leeder et al., 2012). One of the biggest limitations in this study is that the sample is non-professional and therefore difficult to compare with previous findings (Erlacher, Schredl, & Lakus, 2009; Juliff et al., 2015; Lastella, Roach, Halson, Martin, et al., 2015). The athletes in our sample had to work in the evening or morning at the days of measurement, which may influence the athletes´ sleep (Nordin, Knutsson, Sundborn, & Stegmayr, 2005). Another limitation is that the questionnaires were self-reported on a recall basis and the wearing of the actigraphy had to be done self-contained, so that the work-schedule, meeting with friends at the weekend etc. has a strong impact on the results. For that reason it can be said that every measured night is special and difficult to compare with other nights. In future studies this could be prevented by sleep-assessment in a sleep laboratory, or a longitudinal-measure of sleep, so that the daily fluctuations in sleep quality and quantity can be smoothed by the average of several nights.

Conclusion

There was no decrease in subjective and objective sleep parameters prior to competitions compared prior to training, which is maybe influenced by the small sample size of non-elite athletes in team-sports, who were measured only before home games. Also no effect of the breathing intervention on sleep parameters or sleep behaviour and sleep hygiene was found, probably due to the short execution of the breathing technique, other factors influencing sleep, and the small sample size. Nevertheless, athletes tend to sleep less than the recommended 8 hours per night. An overall standardized manual for technical and scoring practise with actigraphy is needed, because of the difference between algorithms and actigraphy-placement for sleep/wake-scoring. Furthermore, when comparing different studies, future studies should take the difference between subjective and actigraphic data into account. The missing first night effect was approved as a new benefit of actigraphy in this study, and makes actigraphy a very useful device for measuring sleep parameters in athletes.

Future coaches, sport-psychologists and the overall surrounding staff of athletes should try to educate athletes as good as possible about sleep and support them in improving sleep quality and quantity. Further research is needed to discover the concrete circumstances of sleep deprivation and sleep habits prior to competitions in connection to athletic performance. Subsequently, prospect studies could test further interventions for athletes to improve their sleep and be prepared for peak performance.

References

Abedelmalek, S., Chtourou, H., Aloui, A., Aouichaoui, C., Souissi, N., & Tabka, Z. (2013). Effect of time of day and partial sleep deprivation on plasma concentrations of IL-6 during a short-term maximal performance. *European journal of applied physiology*, 113, 241-248. doi: 10.1007/s00421-012-2432-7

Acebo, C., Sadeh, A., & Seifer, R. (2005). Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1-to 5-year-old children. *Sleep*, 28, 1568-1577.

Aeschbach, D., Cajochen, C., Landolt, H., & Borbély, A. A. (1996). Homeostatic sleep regulation in habitual short sleepers and long sleepers. *The American journal of physiology*, 270, R41-R53.

Aeschbach, D., Sher, L., Postolache, T. T., Matthews, J. R., Jackson, M. A., & Wehr, T. A. (2003). A longer biological night in long sleepers than in short sleepers. *The Journal of Clinical Endocrinology & Metabolism*, 88, 26-30. doi:10.1210/jc.2002-020827

Agnew Jr, H. W., Webb, W. B., & Williams, R. L. (1966). The first night effect: an EEG study of sleep. *Psychophysiology*, 2, 263-266. doi:10.1111/j.1469-8986.1966.tb02650.x

Allada, R., & Siegel, J. M. (2008). Unearthing the phylogenetic roots of sleep. *Current biology*, 18, R670-R679. doi:10.1016/j.cub.2008.06.033

American Academy of Sleep Medicine. (2008, June 10). Extra Sleep Improves Athletic Performance. *ScienceDaily*. Retrieved July 4, 2016 from www.sciencedaily.com/releases/2008/06/080609071106.htm

Ansfield, M. E., Wegner, D. M., & Bowser, R. (1996). Ironic effects of sleep urgency. *Behaviour Research and Therapy*, *34*(7), 523-531. doi:10.1016/0005-7967(96)00031-9

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour research and therapy*, 44 (12), 1849-1858. doi: 10.1016/j.brat.2005.12.007

Azboy, O., & Kaygisiz, Z. (2009). Effects of sleep deprivation on cardiorespiratory functions of the runners and volleyball players during rest and exercise. *Acta Physiologica Hungarica*, 96 (1), 29-36. doi: 10.1556/APhysiol.96.2009.1.3

Azevedo, C. V., Sousa, I., Paul, K., MacLeish, M. Y., Mondejar, M. T., Sarabia, J. A., ... & Madrid, J. A. (2008). Teaching chronobiology and sleep habits in school and university. *Mind, Brain, and Education*, 2(1), 34-47. doi:10.1111/j.1751-228X.2008.00027.x

Baker, F. C., Maloney, S., & Driver, H. S. (1999). A comparison of subjective estimates of sleep with objective polysomnographic data in healthy men and women. *Journal of Psychosomatic Research*, 47, 335-341. doi:10.1016/S0022-3999(99)00017-3

Benington, J. H., & Heller, H. C. (1995). Restoration of brain energy metabolism as the function of sleep. *Progress in Neurobiology*, 45(4), 347-360. doi:10.1016/0301-0082(94)00057-O

Bhasavanija, T., & Morris, T. (2014). Imagery. In: A.G., Papaioannou &, D. Hackfort (Ed.). *Routledge companion to sport and exercise psychology: global -perspectives and fundamental concepts* (356-371). London: Routledge.

Bird, S. P. (2013). Sleep, recovery, and athletic performance: a brief review and recommendations. *Strength & Conditioning Journal*, 35(5), 43-47. doi:10.1519/SSC.0b013e3182a62e2f

Blumert, P. A., Crum, A. J., Ernsting, M., Volek, J. S., Hollander, D. B., Haff, E. E., & Haff, G. G. (2007). The acute effects of twenty-four hours of sleep loss on the performance of national-caliber male collegiate weightlifters. *Journal of strength and conditioning research*, 21(4), 1146-1154. doi:10.1519/R-21606.1

Blunden, S. L., Chapman, J., & Rigney, G. A. (2012). Are sleep education programs successful? The case for improved and consistent research efforts. *Sleep medicine reviews*, 16(4), 355-370. doi:10.1016/j.smrv.2011.08.002

Bollinger, T., Bollinger, A., Oster, H., & Solbach, W. (2010). Sleep, immunity, and circadian clocks: a mechanistic model. *Gerontology*, 56(6), 574-580. doi:10.1159/000281827

Brown, F. C., Buboltz Jr, W. C., & Soper, B. (2006). Development and evaluation of the Sleep Treatment and Education Program for Students (STEPS*). Journal of American College Health*, 54(4), 231-237. doi:10.3200/JACH.54.4.231-237

Bulbulian, R., Heaney, J. H., Leake, C. N., Sucec, A. A., & Sjoholm, N. T. (1996). The effect of sleep deprivation and exercise load on isokinetic leg strength and endurance. *European journal of applied physiology and occupational physiology*, 73(3), 273-277. doi:10.1007/BF02425487

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry research*, 28(2), 193-213. doi:10.1016/0165-1781(89)90047-4

Carney, C. E., Buysse, D. J., Anco li-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: standardizing prospective sleep self-monitoring. *Sleep*, 35(2), 287-302. doi:10.5665/sleep.1642

Carskadon, M.A., & Dement, W.C. (2011). Monitoring and staging human sleep. In M.H. Kryger, T. Roth, & W.C. Dement (Eds.), *Principles and practice of sleep medicine*, 5th edition, (pp 16-26). St. Louis: Elsevier Saunders. doi:10.1016/B978-1-4160-6645-3.00002-5

Cole, R. J., Kripke, D. F., Gruen, W., Mullaney, D. J., & Gillin, J. C. (1992). Automatic sleep/wake identification from wrist activity. *Sleep*, 15(5), 461-469.

Cote, K. A., Milner, C. E., Osip, S. L., Ray, L. B., & Baxter, K. D. (2003). Waking quantitative electroencephalogram and auditory event-related potentials following experimentally induced sleep fragmentation. *Sleep*, 26(6), 687-694.

Coulon, P., Budde, T., & Pape, H. C. (2012). The sleep relay—the role of the thalamus in central and decentral sleep regulation. *Pflugers Archiv-European Journal of Physiology*, 463(1), 53-71. doi:10.1007/s00424-011-1014-6

Csikszentmihalyi, M. (1990). *Flow: the psychology of optimal experience*. New York, NY: Harper & Row.

Cummiskey, J., Natsis, K., Papathanasiou, E., & Pigozzi, F. (2013). Sleep and Athletic performance. *European Journal of Sports Medicine*, 1(1), 13-22.

Daan, S., Beersma, D. G., & Borbély, A. A. (1984). Timing of human sleep: recovery process gated by a circadian pacemaker. *The American Journal of Physiology*, 246(2), R161-R183.

Davenne, D. (2009). Sleep of athletes–problems and possible solutions. *Biological Rhythm Research*, 40(1), 45-52. doi:10.1080/09291010802067023

De Gennaro, L., Marzano, C., Fratello, F., Moroni, F., Pellicciari, M. C., Ferlazzo, F., ... & Malafosse, A. (2008). The electroencephalographic fingerprint of sleep is genetically determined: a twin study. *Annals of neurology*, 64(4), 455-460. doi:10.1002/ana.21434

De Niet, G., Tiemens, B., Lendemeijer, B., & Hutschemaekers, G. (2009). Music-assisted relaxation to improve sleep quality: meta-analysis. *Journal of advanced nursing*, 65(7), 1356-1364. doi:10.1111/j.1365-2648.2009.04982.x

Diekelmann, S., & Born, J. (2010). The memory function of sleep. *Nature Reviews Neuroscience*, 11(2), 114-126. doi:10.1038/nrn2762

Doran, S. M., Van Dongen, H. P. A., & Dinges, D. F. (2001). Sustained attention performance during sleep deprivation: evidence of state instability. *Archives italiennes de biologie*, 139(3), 253-267. doi:10.5665/sleep.3302

Dosil, J., Cremades, J. G., & Rivera, S. (2014). Psychological skills training and programs. In: A.G., Papaioannou &, D. Hackfort (Ed.). *Routledge companion to sport and exercise psychology: global -perspectives and fundamental concepts* (327-342). London: Routledge.

Drummond, S. P., Anderson, D. E., Straus, L. D., Vogel, E. K., & Perez, V. B. (2012). The effects of two types of sleep deprivation on visual working memory capacity and filtering efficiency. *PLoS ONE* 7(4): e35653. doi:10.1371/journal.pone.0035653

Edwards, B. J., & Waterhouse, J. (2009). Effects of one night of partial sleep deprivation upon diurnal rhythms of accuracy and consistency in throwing darts. *Chronobiology international*, 26(4), 756-768. doi:10.1080/07420520902929037

Elmenhorst, E. M., Elmenhorst, D., Luks, N., Maass, H., Vejvoda, M., & Samel, A. (2008). Partial sleep deprivation: impact on the architecture and quality of sleep. *Sleep medicine,* 9(8), 840-850. doi:10.1016/j.sleep.2007.07.021

Erlacher, D., Ehrlenspiel, F., Adegbesan, O. A., & Galal El-Din, H. (2011). Sleep habits in German athletes before important competitions or games. *Journal of sports sciences*, 29(8), 859-866. doi:10.1080/02640414.2011.565782

Erlacher, D., Gebhart, C., Ehrlenspiel, F., Blischke, K., & Schredl, M. (2012). Schlaf und Sport. Motorisches Gedächtnis, Wettkampfleistung und Schlafqualität. *Zeitschrift für Sportpsychologie*, 19(1), 4-15. doi:10.1026/1612-5010/a000063

Erlacher, D., Schredl, M., Ehrlenspiel, F., & Bosing, M. (2009). Subjective sleep quality and state anxiety of high-school students prior to a final sport exam. *Advances in psychology research*, 63, 179-186.

Erlacher, D., Schredl, M., & Lakus, G. (2009). Subjective sleep quality prior to home and away games for female volleyball players. *International Journal of Dream Research*, 2, 70-72.

Feldman, G., Greeson, J., & Senville, J. (2010). Differential effects of mindful breathing, progressive muscle relaxation, and loving-kindness meditation on decentering and negative reactions to repetitive thoughts. *Behaviour research and therapy,* 48, 1002-1011. doi:10.1016/j.brat.2010.06.006

Fletcher, D., & Hanton, S. (2001). The relationship between psychological skills usage and competitive anxiety responses. *Psychology of Sport and Exercise*, 2(2), 89-101. doi:10.1016/S1469-0292(00)00014-5

Fullagar, H. H., Skorski, S., Duffield, R., Hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports medicine*, 45(2), 161-186. doi:10.1007/s40279-014-0260-0

Gigli, G. L., & Valente, M. (2013). Should the definition of “sleep hygiene” be antedated of a century? A historical note based on an old book by Paolo Mantegazza, rediscovered. *Neurological Sciences*, 34(5), 755-760. doi:10.1007/s10072-012-1140-8

Halson, S. L. (2008). Nutrition, sleep and recovery. *European Journal of sport science*, 8(2), 119-126. doi: 10.1080/17461390801954794

Halson, S. L. (2014). Sleep in elite athletes and nutritional interventions to enhance sleep. *Sports Medicine*, 44(1), 13-23. doi:10.1007/s40279-014-0147-0

Hardy, L., Jones, J.G. & Gould, D. (1996). Understanding psychological preparation for sport: Theory and practice of elite performers. Chichester, UK: Wiley

Harrison, Y., & Horne, J. A. (2000). The impact of sleep deprivation on decision making: a review. *Journal of Experimental Psychology: Applied*, 6(3), 236-249. doi:10.1037//1076-898X.6.3.236

Harvey, A. G., & Payne, S. (2002). The management of unwanted pre-sleep thoughts in insomnia: distraction with imagery versus general distraction. *Behaviour research and therapy*, 40(3), 267-277. doi:10.1016/S0005-7967(01)00012-2

Inoué, S., Honda, K., & Komoda, Y. (1995). Sleep as neuronal detoxification and restitution. *Behavioural brain research*, 69(1-2), 91-96. doi:10.1016/0166-4328(95)00014-K

Irwin, M. R. (2015). Why sleep is important for health: a psychoneuroimmunology perspective. *Annual Review of Psychology*, 66(1), 143-172. doi:10.1146/annurev-psych-010213-115205

Jackowska, M., Dockray, S., Hendrickx, H., & Steptoe, A. (2011). Psychosocial factors and sleep efficiency: discrepancies between subjective and objective evaluations of sleep. *Psychosomatic Medicine*, 73(9), 810-816. doi:10.1097/PSY.0b013e3182359e77

Jarraya, S., Jarraya, M., Chtourou, H., & Souissi, N. (2014). Effect of time of day and partial sleep deprivation on the reaction time and the attentional capacities of the handball goalkeeper. *Biological Rhythm Research*, 45(2), 183-191. doi:10.1080/09291016.2013.787685

Juliff, L. E., Halson, S. L., & Peiffer, J. J. (2015). Understanding sleep disturbance in athletes prior to important competitions. *Journal of Science and Medicine in Sport,* 18(1), 13-18. doi:10.1016/j.jsams.2014.02.007

Kawada, T. (2008). Agreement rates for sleep/wake judgments obtained via accelerometer and sleep diary: A comparison. *Behavior research methods*, 40(4), 1026-1029. doi:10.3758/BRM.40.4.1026

Killgore, W. D., Kamimori, G. H., & Balkin, T. J. (2011). Caffeine protects against increased risk-taking propensity during severe sleep deprivation. *Journal of sleep research*, 20(3), 395-403. doi: 10.1111/j.1365-2869.2010.00893.x

Klerman, E. B., & Dijk, D. J. (2005). Interindividual variation in sleep duration and its association with sleep debt in young adults. *Sleep,* 28(10), 1253-1259.

Kölling, S., Endler, S., Ferrauti, A., Meyer, T., & Kellmann, M. (2015). Comparing Subjective With Objective Sleep Parameters Via Multisensory Actigraphy in German

Physical Education Students. *Behavioral sleep medicine*, 4, 1-17. doi:10.1080/15402002.2015.1017096

Kotronoulas, G. C., Papadopoulou, C. N., Papapetrou, A., & Patiraki, E. (2011). Psychometric evaluation and feasibility of the Greek Pittsburgh Sleep Quality Index (GR-PSQI) in patients with cancer receiving chemotherapy. *Supportive Care in Cancer*, 19(11), 1831-1840. doi:10.1007/s00520-010-1025-4

Kripke, D. F., Hahn, E. K., Grizas, A. P., Wadiak, K. H., Loving, R. T., Poceta, J. S., ... & Kline, L. E. (2010). Wrist actigraphic scoring for sleep laboratory patients: algorithm development. *Journal of sleep research*, 19(4), 612-619. doi:10.1111/j.1365-2869.2010.00835.x

Landmann, N., Kuhn, M., Piosczyk, H., Feige, B., Baglioni, C., Spiegelhalder, K., ... & Nissen, C. (2014). The reorganisation of memory during sleep. *Sleep medicine reviews*, 18(6), 531-541. doi:10.1016/j.smrv.2014.03.005

Lastella, M., Lovell, G. P., & Sargent, C. (2014). Athletes' precompetitive sleep behaviour and its relationship with subsequent precompetitive mood and performance. *European journal of sport science*, 14(sup1), S123-S130. doi:10.1080/17461391.2012.660505

Lastella, M., Roach, G. D., Halson, S. L., Martin, D. T., West, N. P., & Sargent, C. (2015). Sleep/wake behaviour of endurance cyclists before and during competition. *Journal of sports sciences*, 33(3), 293-299. doi10.1080/02640414.2014.942690

Lastella, M., Roach, G. D., Halson, S. L., & Sargent, C. (2015). Sleep/wake behaviours of elite athletes from individual and team sports. *European journal of sport science*, 15(2), 94-100. doi:10.1080/17461391.2014.932016

Leeder, J., Glaister, M., Pizzoferro, K., Dawson, J., & Pedlar, C. (2012). Sleep duration and quality in elite athletes measured using wristwatch actigraphy. *Journal of sports sciences*, 30(6), 541-545. doi:10.1080/02640414.2012.660188

Lockley, S. W., Skene, D. J., & Arendt, J. (1999). Comparison between subjective and actigraphic measurement of sleep and sleep rhythms. *Journal of sleep research*, 8(3), 175-183. doi:10.1046/j.1365-2869.1999.00155.x

Mah, C. D., Mah, K. E., Kezirian, E. J., & Dement, W. C. (2011). The effects of sleep extension on the athletic performance of collegiate basketball players. *Sleep*, 34(7), 943-950. doi:10.5665/SLEEP.1132

Martin, J. L., & Hakim, A. D. (2011). Wrist actigraphy. *Chest Journal*, 139(6), 1514-1527. doi:10.1378/chest.10-1872

Mastin, D. F., Bryson, J., & Corwyn, R. (2006). Assessment of sleep hygiene using the Sleep Hygiene Index. *Journal of behavioral medicine*, 29(3), 223-227. doi:10.1007/s10865-006-9047-6

Maurer, J. T., Weeß, H. G., & Schredl, M. (2013). Physiologische Grundlagen des normalen und gestörten Schlafes. In B. A. Stuck, J. T. Maurer, M. Schredl, H-G. Weeß (Eds), *Praxis der Schlafmedizin* (pp. 1-20). Berlin: Springer. doi: 10.1007/978-3-540-88700-3

Mollayeva, T., Thurairajah, P., Burton, K., Mollayeva, S., Shapiro, C. M., & Colantonio, A. (2016). The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep Medicine Reviews*, 25, 52-73. doi:10.1016/j.smrv.2015.01.009

Moseley, L., & Gradisar, M. (2009). Evaluation of a school-based intervention for adolescent sleep problems. *Sleep*, 32(3), 334.

Myllymäki, T., Kyröläinen, H., Savolainen, K., Hokka, L., Jakonen, R., Juuti, T., ... & Rusko, H. (2011). Effects of vigorous late-night exercise on sleep quality and cardiac autonomic activity. *Journal of sleep research*, 20(1 Pt 2), 146-153. doi:10.1111/j.1365-2869.2010.00874.x

Natale, V., Adan, A., & Fabbri, M. (2009). Season of birth, gender, and social-cultural effects on sleep timing preferences in humans. *Sleep*, 32(3), 423-426.

Nena, E., Steiropoulos, P., Papanas, N., Kougkas, D., Zarogoulidis, P., & Constantinidis, T. C. (2014). Greek financial crisis: From loss of money to loss of sleep?. *Hippokratia*, 18(2), 135-138.

Nilsson, J. P., Söderström, M., Karlsson, A. U., Lekander, M., Åkerstedt, T., Lindroth, N. E., & Axelsson, J. (2005). Less effective executive functioning after one night's sleep deprivation. *Journal of sleep research*, 14(1), 1-6. doi:10.1111/j.1365-2869.2005.00442.x

Nordin, M., Knutsson, A., Sundbom, E., & Stegmayr, B. (2005). Psychosocial factors, gender, and sleep. *Journal of Occupational Health Psychology*, 10(1), 54-63. doi:10.1037/1076-8998.10.1.54

Ogilvie, R. D. (2001). The process of falling asleep. *Sleep medicine reviews*, 5(3), 247-270. doi:10.1053/smrv.2001.0145

Oliver, S. J., Costa, R. J., Laing, S. J., Bilzon, J. L., & Walsh, N. P. (2009). One night of sleep deprivation decreases treadmill endurance performance. *European journal of applied physiology*, 107(2), 155-161. doi:10.1007/s00421-009-1103-9

Pace-Schott, E. F., & Hobson, J. A. (2002). The neurobiology of sleep: genetics, cellular physiology and subcortical networks. *Nature Reviews Neuroscience*, 3(8), 591-605. doi:10.1038/nrn895

Paul, M., & Garg, K. (2012). The effect of heart rate variability biofeedback on performance psychology of basketball players. *Applied Psychophysiology and Biofeedback*, 37(2), 131-144. doi:10.1007/s10484-012-9185-2.

Reilly, T., & Piercy, M. (1994). The effect of partial sleep deprivation on weight-lifting performance. *Ergonomics*, 37(1), 107-115. doi:10.1080/00140139408963628

Reyner, L. A., & Horne, J. A. (2013). Sleep restriction and serving accuracy in performance tennis players, and effects of caffeine. *Physiology & behavior*, 120, 93-96. doi:10.1016/j.physbeh.2013.07.002

Romans, S. E., Kreindler, D., Einstein, G., Laredo, S., Petrovic, M. J., & Stanley, J. (2015). Sleep quality and the menstrual cycle. *Sleep medicine*, 16(4), 489-495. doi:10.1016/j.sleep.2014.12.001

Romyn, G., Robey, E., Dimmock, J. A., Halson, S. L., & Peeling, P. (2015). Sleep, anxiety and electronic device use by athletes in the training and competition environments. *European journal of sport science*, 16(3), 301-308. doi:10.1080/17461391.2015.1023221

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: an update. *Sleep medicine reviews*, 15(4), 259-267. doi:10.1016/j.smrv.2010.10.00

Sadeh, A., Alster, J., Urbach, D., & Lavie, P. (1989). Actigraphically based automatic bedtime sleep-wake scoring: validity and clinical applications. *Journal of Ambulatory Monitoring*, 2(3), 209-216.

Sadeh, A., Sharkey, K. M., & Carskadon, M. A. (1994). Activity-based sleep—wake identification: an empirical test of methodological issues. *Sleep*, 17(3), 201-207.

Samuels, C. H. (2012). Jet lag and travel fatigue: a comprehensive management plan for sport medicine physicians and high-performance support teams. *Clinical Journal of Sport Medicine*, 22(3), 268-273. doi:10.1097/JSM.0b013e31824d2eeb.

Savis, J. C. (1994). Sleep and athletic performance: Overview and implications for sport psychology. *The Sport Psychologist*, 8, 111–125.

Scott, W. A. (2002). Maximizing performance and the prevention of injuries in competitive athletes. *Current sports medicine reports*, 1(3), 184-190. doi:10.1249/00149619-200206000-00010

Sehgal, A., & Mignot, E. (2011). Genetics of sleep and sleep disorders. *Cell*, 146(2), 194-207. doi:10.1016/j.cell.2011.07.004

Skein, M., Duffield, R., Edge, J., Short, M. J., & Mundel, T. (2011). Intermittent-sprint performance and muscle glycogen after 30 h of sleep deprivation. *Medicine & Science in Sport & Exercise*, 43(7), 1301-11. doi:10.1249/MSS.0b013e31820abc5a

Slater, J. A., Botsis, T., Walsh, J., King, S., Straker, L. M., & Eastwood, P. R. (2015). Assessing sleep using hip and wrist actigraphy. *Sleep and Biological Rhythms*, 13(2), 172-180. doi:10.1111/sbr.12103

Smith, M. T. (2015). Why an Actigraphy Manual Is Needed. *Behavioral sleep medicine*, 13(sup1), S1-S3. doi:10.1080/15402002.2015.1055947

Smith, M. T., Finan, P. H., Buenaver, L. F., Robinson, M., Haque, U., Quain, A., ... & Haythornthwaite, J. A. (2015). Cognitive–Behavioral Therapy for Insomnia in Knee

Osteoarthritis: A Randomized, Double-Blind, Active Placebo–Controlled Clinical Trial. *Arthritis & Rheumatology*, 67(5), 1221-1233. doi:10.1002/art.39048

Soric, M., Turkalj, M., Kucic, D., Marusic, I., Plavec, D., & Misigoj-Durakovic, M. (2013). Validation of a multi-sensor activity monitor for assessing sleep in children and adolescents. *Sleep medicine*, 14(2), 201-205. doi:10.1016/j.sleep.2012.11.003

Souissi, N., Sesboüé, B., Gauthier, A., Larue, J., & Davenne, D. (2003). Effects of one night's sleep deprivation on anaerobic performance the following day. *European Journal of Applied Physiology*, 89(3-4), 359-366. doi:10.1007/s00421-003-0793-7

Sousa, D., Cortez, I., Araújo, J.F., Azevedo, D., & Macêdo, C.V. (2007). The effect of a sleep hygiene education program on the sleep–wake cycle of Brazilian adolescent students. *Sleep and Biological Rhythms*, 5(4), 251-258. doi:10.1111/j.1479-8425.2007.00318.x

Stepanski, E. J., & Wyatt, J. K. (2003). Use of sleep hygiene in the treatment of insomnia. *Sleep medicine reviews*, 7(3), 215-225. doi:10.1053/smrv.2001.0246

Strack, B., & Gevirtz, R. (2011). Getting to the heart of the matter: Heart rate variability biofeedback for enhanced performance. *Biofeedback and neurofeedback applications in sport psychology*, 145-174.

Taheri, M., & Arabameri, E. (2012). The effect of sleep deprivation on choice reaction time and anaerobic power of college student athletes. *Asian Journal of Sports Medicine*, 3, 15–20. doi:10.5812/asjsm.34719

Takács, J., Bódizs, R., Ujma, P. P., Horváth, K., Rajna, P., & Harmat, L. (2016). Reliability and validity of the Hungarian version of the Pittsburgh Sleep Quality Index (PSQI-HUN): comparing psychiatric patients with control subjects. *Sleep and Breathing*, 1-7. doi:10.1007/s11325-016-1347-7

Teng, E., Lastella, M., Roach, G. D., Sargent, C. (2011). The effect of training load on sleep quality and sleep perception in elite male cyclists. In: G. A. Kennedy, C. Sargent (Eds). *Little clock, big clock: Molecular to physiological clocks*. Australasian Chronobiology Society, Melbourne, Australia, pp. 05-10.

Thayer, J. F., Hansen, A. L., & Johnsen, B. H. (2010). The non-invasive assessment of autonomic influences on the heart using impedance cardiography and heart rate variability. In: A. Steptoe (Eds.). *Handbook of behavioral medicine* (pp. 723-740). Springer New York. doi:10.1007/978-0-387-09488-5_47

Thorpy M., Chesson, A., Derderian, S., Kader, G., Millman, R., Potolicchio, S., … Strollo, P. J. (1995), Practice Parameters for the use of actigraphy in the clinical assessment of sleep disorders. *Sleep*, 18, 285-287.

Thun, E., Bjorvatn, B., Flo, E., Harris, A., & Pallesen, S. (2015). Sleep, circadian rhythms, and athletic performance. *Sleep medicine reviews*, 23, 1-9. doi:10.1016/j.smrv.2014.11.003

Tryon, W. W. (2004). Issues of validity in actigraphic sleep assessment. *Sleep*, 27(1), 158-165.

Tsai, H. J., Kuo, T. B., Lee, G. S., & Yang, C. C. (2015). Efficacy of paced breathing for insomnia: enhances vagal activity and improves sleep quality. *Psychophysiology*, 52(3), 388-396. doi:10.1111/psyp.12333

Vealey, R.S. (2007). Mental skills training in sport. In G. Tenenbaum & R. Eklund (Eds.), Handbook of sport psychology (3rd ed.) (pp.287–309). Hoboken, NJ: Wiley. doi:10.1002/9781118270011.ch13

Venter, R. E. (2012). Role of sleep in performance and recovery of athletes: a review article. *South African Journal for Research in Sport, Physical Education and Recreation*, 34(1), 167-184.

Vgontzas, A. N., Zoumakis, E., Bixler, E. O., Lin, H. M., Follett, H., Kales, A., & Chrousos, G. P. (2004). Adverse effects of modest sleep restriction on sleepiness, performance, and inflammatory cytokines. *The journal of Clinical Endocrinology & Metabolism*, 89(5), 2119-2126. doi:10.1210/jc.2003-031562

Walch, O. J., Cochran, A., & Forger, D. B. (2016). A global quantification of “normal” sleep schedules using smartphone data. *Science Advances*, 2(5), e1501705. doi: 10.1126/sciadv.1501705

Walker, M. P., Brakefield, T., Morgan, A., Hobson, J. A., & Stickgold, R. (2002). Practice with sleep makes perfect: sleep-dependent motor skill learning. *Neuron*, 35, 205-211. doi:10.1016/S0896-6273(02)00746-8

Walker, M. P., & Stickgold, R. (2005). It's practice, with sleep, that makes perfect: implications of sleep-dependent learning and plasticity for skill performance. *Clinics in sports medicine*, 24(2), 301-317. doi:10.1016/j.csm.2004.11.002

Walters, P. H. (2002). Sleep, the Athlete, and Performance. *Strength & Conditioning Journal*, 24(2), 17-24. doi:10.1519/00126548-200204000-00005

Waterhouse, J., Atkinson, G., Edwards, B., & Reilly, T. (2007). The role of a short post-lunch nap in improving cognitive, motor, and sprint performance in participants with partial sleep deprivation. *Journal of sports sciences*, 25(14), 1557-1566. doi:10.1080/02640410701244983

Webster, J. B., Kripke, D. F., Messin, S., Mullaney, D. J., & Wyborney, G. (1982). An activity-based sleep monitor system for ambulatory use. *Sleep*, 5(4), 389.

Woolfolk, R. L., & McNulty, T. F. (1983). Relaxation treatment for insomnia: A component analysis. *Journal of Consulting and Clinical Psychology*, 51(4), 495. doi:10.1037/0022-006X.51.4.495

Xie, L., Kang, H., Xu, Q., Chen, M. J., Liao, Y., Thiyagarajan, M., ... & Takano, T. (2013). Sleep drives metabolite clearance from the adult brain. *Science*, 342(6156), 373-377. doi:10.1126/science.1241224

Yasuma, F., & Hayano, J. I. (2004). Respiratory sinus arrhythmia: why does the heartbeat synchronize with respiratory rhythm?. *Chest Journal*, 125(2), 683-690. doi:10.1378/chest.125.2.683

Zinkhan, M., Berger, K., Hense, S., Nagel, M., Obst, A., Koch, B., ... & Happe, S. (2014). Agreement of different methods for assessing sleep characteristics: a comparison of two actigraphs, wrist and hip placement, and self-report with polysomnography. *Sleep* medicine, 15(9), 1107-1114. doi:10.1016/j.sleep.2014.04.015

Appendizes

APPENDIX A – Consent Form

Informed consent form for participation in a research study

1. Title of the study

Breath and Sleep: A relaxation-technique to prevent the decrease in pre-competition sleep quality.

2. Aim of the study

The aimof this study is to investigate the effect of an intervention on the pre-competition sleep-quality.

3. Description of research activities

The participants will wear two actigraph-devices three times for two nights at the wrist and ankle. Furthermore they will complete a sleep-diary and a questionnaire before going to bed and after waking up. The first night will take place at a night pre-training condition, whereas the second and third measurement will take place at nights prior to competitions. Two weeks before the third measurement the athletes will participate in a workshop about sleep-hygiene, the importance of sleep for athletes and tips for a better sleep quality. Their participation will be entirely voluntary.

4. Risks/ discomfort involved

This study does not carry any risks, and the participation will be on a voluntary basis.

5. Expected impact

This investigation will help to understand effect of knowledge about sleep and knowledge about ways to influence sleep on the athletes´ sleep-quality and -quantity. This research can be used as a basis to optimize athletes´ sleep-quality as well as –quantity and thereby athletic-performance and well-being.

Dissemination of results

The athletes will be asked to provide only the signature on this consent form, as a confirmation that they accepted to participate in the study voluntary and that their data will be used only for research purposes and treated confidentially.

Further Information

Do not hesitate to make questions regarding the aim or design of this study. If you have any doubts or questions, please ask me for clarifications.

Freedom of consent

You are a volunteer participant. You are free to withdraw your consent now or later

Participant´s declaration

I read this form and I understand the procedures involved. I agree to participate in this study.

Date: ___/___/________

[Name and signature of participant]: ______________________________

[Nam and signature of researcher]: ______________________________

[Name and signature of witness]: ________________________________

Dennis Redlich (dennis.redlich@gmx.de) University of Thessaly

APPENDIX B – Greek self-assessment scale of the Common European Framework of Reference for Languages: Learning, teaching, assessment (CEFR)

ΕΥΡΩΠΑΪΚΑ ΕΠΙΠΕΔΑ – ΠΙΝΑΚΑΣ ΑΥΤΟΑΞΙΟΛΟΓΗΣΗΣ

		A1	A2	B1	B2	C1	C2
Κ Α Τ Α Ν Ο Η Σ Η	Προφορική	Μπορώ να κατανοώ βασικές λέξεις και πολύ συνηθισμένες εκφράσεις σχετικά με το άτομό μου, την οικογένειά μου και το άμεσο περιβάλλον μου, με την προϋπόθεση ότι ο συνομιλητής μου μιλάει αργά και καθαρά.	Μπορώ να κατανοώ εκφράσεις εκτός κειμένου και λέξεις που χρησιμοποιούνται πολύ συχνά και αφορούν το άτομό μου, την οικογένειά μου αγορές, εργασία ή το άμεσο περιβάλλον μου. Μπορώ επίσης να κατανοώ το νόημα ενός απλού, σαφούς και σύντομου μηνύματος.	Μπορώ να κατανοώ τα κύρια σημεία μιας συζήτησης, με την προϋπόθεση ότι η γλώσσα που χρησιμοποιείται είναι απλή και σαφής και τα θέματα της συζήτησης οικεία, όπως για παράδειγμα εργασία, σχολείο, καθημερινές δραστηριότητες κ.λπ. Μπορώ να κατανοώ το κεντρικό θέμα ραδιοφωνικών και τηλεοπτικών εκπομπών, εάν αυτό παρουσιάζει ενδιαφέρον για μένα και οι συνομιλητές μιλούν αργά και καθαρά.	Μπορώ να κατανοώ διαλέξεις με σύνθετη επιχειρηματολογία, εάν το θέμα είναι αρκετά οικείο. Μπορώ να κατανοώ το μεγαλύτερο μέρος των τηλεοπτικών δελτίων ειδήσεων και των ντοκιμαντέρ. Μπορώ να κατανοώ τις περισσότερες κινηματογραφικές ταινίες αν η γλώσσα είναι η καθομιλουμένη.	Μπορώ να κατανοώ μια μακροσκελή συζήτηση, ακόμη και αν δεν είναι καλά δομημένη και οι ιδέες δεν είναι σαφείς. Μπορώ να κατανοώ τηλεοπτικές εκπομπές και κινηματογραφικές ταινίες χωρίς ιδιαίτερη προσπάθεια.	Δεν έχω καμία δυσκολία να κατανοώ τον προφορικό λόγο είτε σε συνθήκες άμεσης επικοινωνίας είτε όταν αυτός εκφέρεται από τα μέσα μαζικής ενημέρωσης ακόμη και εάν οι άλλοι μιλούν γρήγορα, αρκεί να υπάρχει ο χρόνος για να εξοικειωθώ με μια συγκεκριμένη ιδιόλεκτο.
	Γραπτή (ανάγνωση)	Μπορώ να κατανοώ λέξεις και φράσεις πολύ απλές όπως για παράδειγμα αυτές που περιέχονται σε αγγελίες, σε αφίσες και σε διαφημιστικά φυλλάδια.	Μπορώ να διαβάζω ένα πολύ απλό και σύντομο κείμενο, να βρίσκω μια συγκεκριμένη πληροφορία σε συνοπτικά κείμενα όπως μικρές αγγελίες, διαφημιστικά φυλλάδια, καταλόγους εστιατορίων, έντυπα με ώρες αφίξεων και αναχωρήσεων μέσων μαζικής μεταφοράς. Μπορώ επίσης να κατανοώ μια σύντομη και απλή προσωπική επιστολή.	Μπορώ να κατανοώ κείμενα που είναι γραμμένα στην καθομιλουμένη ή σε γλώσσα σχετική με τη δουλειά μου. Μπορώ να κατανοώ την περιγραφή ενός γεγονότος, ή την έκφραση συναισθημάτων και ευχών σε μια προσωπική επιστολή.	Μπορώ να διαβάζω άρθρα και συνεντεύξεις που εκφράζουν προσωπικές θέσεις και απόψεις .Μπορώ να κατανοώ ένα σύγχρονο λογοτεχνικό κείμενο σε πρόζα.	Μπορώ να κατανοώ λογοτεχνικά ή μη κείμενα μακροσκελή και πολύπλοκα και να αντιλαμβάνομαι τις διαφορές του ύφους. Μπορώ να κατανοώ εξειδικευμένα άρθρα και μακροσκελείς τεχνικές οδηγίες, ακόμη και αν δεν είναι σχετικές με την ειδικότητά μου.	Μπορώ να διαβάζω χωρίς προσπάθεια και να εμβαθύνω σε κάθε είδος κειμένου, όπως για παράδειγμα ένα εγχειρίδιο, ένα εξειδικευμένο άρθρο ή ένα λογοτεχνικό έργο.
Ο Μ Ι Λ Ι Α	Επικοινωνία	Μπορώ να επικοινωνώ με απλό τρόπο, με την προϋπόθεση ότι ο συνομιλητής μου θα επαναλαμβάνει ή θα επαναδιατυπώνει τις φράσεις του πιο αργά και θα με βοηθάει να εκφράσω αυτό που θέλω να πω. Μπορώ να θέτω απλές ερωτήσεις πάνω σε θέματα οικεία ή άμεσης προτεραιότητας και να δίνω ανάλογες απαντήσεις.	Μπορώ να επικοινωνώ σε καθημερινές περιστάσεις όπου χρειάζεται να ανταλλάσσω απλές πληροφορίες για δραστηριότητες και θέματα οικεία. Μπορώ να έχω πολύ σύντομες συνομιλίες, ακόμη και αν σε γενικές γραμμές δεν καταλαβαίνω αρκετά για να παρακολουθήσω μια συζήτηση.	Μπορώ να αντεπεξέρχομαι λεκτικά στις περισσότερες καταστάσεις που είναι δυνατόν να συναντήσει κανείς όταν ταξιδεύει στο εξωτερικό. Μπορώ να συμμετέχω χωρίς προετοιμασία σε μια συζήτηση πάνω σε θέματα οικεία ή με προσωπικό ενδιαφέρον ή με αναφορές στην καθημερινή ζωή (όπως για παράδειγμα οικογένεια, προσωπικές ασχολίες, εργασία, ταξίδια, επικαιρότητα).	Μπορώ να επικοινωνώ με αυθορμητισμό και άνεση, ώστε η συζήτηση να εκτυλίσσεται με ομαλό τρόπο. Μπορώ να συμμετέχω ενεργά σε μια συζήτηση υπό κανονικές συνθήκες, να εκθέτω και να υπερασπίζομαι τις απόψεις μου.	Μπορώ να εκφράζομαι αυθόρμητα και με συνεχή λόγο χωρίς να ψάχνω να βρω τις κατάλληλες λέξεις. Μπορώ να χρησιμοποιώ τη γλώσσα αβίαστα και αποτελεσματικά σε κοινωνικές και επαγγελματικές σχέσεις. Μπορώ να εκφράζω τις ιδέες και τις απόψεις μου με ακρίβεια και να συνδέω τις παρεμβάσεις μου με αυτές των συνομιλητών μου.	Μπορώ να συμμετέχω χωρίς προσπάθεια σε κάθε συζήτηση και να έχω άνεση με τις ιδιωματικές και τις καθημερινές εκφράσεις. Μπορώ να εκφράζω με ευχέρεια και με ακρίβεια τις λεπτές αποχρώσεις των εννοιών. Μπορώ να αντεπεξέρχομαι σε μια εννοιολογική δυσκολία με τρόπο που να μη γίνει κατανοητό από το συνομιλητή μου.
	Προφορική έκφραση	Μπορώ να χρησιμοποιώ απλές εκφράσεις για να περιγράψω την κατοικία μου και τους ανθρώπους που γνωρίζω.	Μπορώ να χρησιμοποιώ απλές προτάσεις για να περιγράψω την οικογένειά μου, τους άλλους ανθρώπους, την κατάρτισή μου, την τωρινή ή πρόσφατη επαγγελματική μου ενασχόληση.	Μπορώ να χειρίζομαι με απλό τρόπο εκφράσεις προκειμένου να περιγράψω εμπειρίες, γεγονότα, όνειρα, τις ελπίδες, τους στόχους μου. Μπορώ να εκφράζω με συντομία τις απόψεις και τα σχέδιά μου. Μπορώ να διηγούμαι την πλοκή μιας κινηματογραφικής ταινίας και να περιγράφω τις αντιδράσεις μου.	Μπορώ να εκφράζομαι με σαφή και λεπτομερή τρόπο πάνω σε θέματα που άπτονται των ενδιαφερόντων μου. Μπορώ να αναπτύσσω την άποψή μου σε ένα θέμα της επικαιρότητας και να εξηγώ τα προτερήματα και τα μειονεκτήματα των διαφορετικών προσεγγίσεων στο θέμα.	Μπορώ να παρουσιάζω με σαφείς και περιεκτικές περιγραφές ένα πολύπλοκο θέμα, συνδέοντας τις επιμέρους έννοιες, αναπτύσσοντας τα κύρια σημεία και ολοκληρώνοντας τις παρεμβάσεις μου με προσωπικό τρόπο.	Μπορώ να κάνω μια περιγραφή ή να αναπτύσσω μια επιχειρηματολογία με σαφή και ρέοντα λόγο και με ύφος προσαρμοσμένο στις περιστάσεις δομώντας μια παρουσίαση με λογικό τρόπο και βοηθώντας τους ακροατές μου να υπογραμμίζουν και να ανακαλούν στη μνήμη τους τα κύρια σημεία.
Γ Ρ Α Φ Η	Γραφή	Μπορώ να γράφω σε μια καρτ ποστάλ ένα σύντομο μήνυμα με απλά λόγια (π.χ. τους χαιρετισμούς σε κάποιον κατά τη διάρκεια των διακοπών μου). Μπορώ να συμπληρώνω τα προσωπικά μου στοιχεία (όνομα, εθνικότητα, διεύθυνση) σ' ένα ερωτηματολόγιο, όπως για παράδειγμα σε ένα έντυπο ξενοδοχείου.	Μπορώ να γράφω σημειώσεις και μηνύματα με απλό και σύντομο τρόπο. Μπορώ να γράφω μια πολύ απλή προσωπική επιστολή όπως για παράδειγμα για να εκφράσω τις ευχαριστίες μου σε κάποιον.	Μπορώ να γράφω ένα απλό και δομημένο κείμενο πάνω σε θέματα οικεία ή με προσωπικό ενδιαφέρον. Μπορώ να γράφω προσωπικές επιστολές για να διηγηθώ εμπειρίες και εντυπώσεις.	Μπορώ να γράφω κείμενο σαφές και λεπτομερές πάνω σε μια μεγάλη ποικιλία θεμάτων σχετικών με τα ενδιαφέροντά μου. Μπορώ να γράφω μια μελέτη ή μια αναφορά μεταφέροντας μια πληροφορία ή εκθέτοντας ένα επιχείρημα το οποίο υποστηρίζει ή αντικρούει τη συγκεκριμένη άποψη. Μπορώ να γράφω προσωπικές ή επίσημες επιστολές που αποδίδουν με λεπτές αποχρώσεις προσωπικά γεγονότα και εμπειρίες.	Μπορώ να εκφράζομαι αναπτύσσοντας τις απόψεις μου μέσα από ένα κείμενο σαφές και καλά δομημένο. Μπορώ να γράφω μια επιστολή, μια μελέτη, μια αναφορά αναπτύσσοντας ένα πολύπλοκο θέμα και τονίζοντας τα σπουδαιότερα σημεία του. Μπορώ να υιοθετήσω ένα ύφος προσαρμοσμένο στις ανάγκες εκφώνησης του λόγου μου.	Μπορώ να γράφω ένα σαφές κείμενο με ροή και ύφος προσαρμοσμένο στις περιστάσεις. Μπορώ να συντάσσω επιστολές, αναφορές ή πολύπλοκα άρθρα με δομή σαφή που να επιτρέπουν στον αναγνώστη να αντιλαμβάνεται και να απομνημονεύει τα κύρια σημεία. Μπορώ να παρουσιάζω περιληπτικά και με κριτικό τρόπο μια εργασία επαγγελματική ή ένα λογοτεχνικό έργο.

APPENDIX C – Sleep log

Personal information (*EXAMPLE ANSWERS*)

1. What is your name? Πως ονομάζεσαι; (*George Examplos*)

____

4. Which gender are you? Τι γένος είσαι; (*male*)

female: □ male: □

3. How old are you? Πόσο χρονών είσαι; (*28 years*)

I am ________ years old.

4. What is your highest graduation?Ποιά είναι η ανώτερη αποφοίτησή σου; (*high-school*)

____

5.	Do you feel stressed in your actual life-situation? Νιώθεις αγχωμένος στην καθημερινή σου ζωή;	□ Not at all □ Slightly □ Somewhat □ Much □ Very much

Information about your sport

6. What is your major sport?Ποιό είναι το κύριο άθλημά σου; (*soccer*)

____

7. At which age did you start participating in your sport? Σε ποια ηλικία ξεκίνησες να συμμετάσχεις στο άθλημά σου; (*with 12 years*)

With _______ years.

Consensus Sleep Diary - E (Please Complete Before Bed)

11a.	How many times did you nap or doze? Πόσες φορές παίρνεις έναν υπνάκο ή κοιμάσαι ελαφριά? (*2times*)	______________________
11b.	In total, how long did you nap or doze? Στο σύνολο , πόση ώρα παίρνεις έναν υπνάκο ή κοιμάσαι ελαφριά; (*40 min*)	______________________
12a.	How many drinks containing alcohol did you have? Πόσα ποτά με περιεκτικότητα σε αλκοόλ είχες;(*3 drinks*)	______________________
12b.	What time was your last alcoholic drink? Τι ώρα ήπιες το τελευταίο σου ποτό με αλκοόλ; (*19:00*)	______________________
13a.	How many caffeinated drinks (coffee, tea, coke, energy drinks) did you have? Πόσα ποτά με περιεκτικότητα σε καφεΐνη (καφές, τσάι, κόκα κόλα, ενεργειακά ποτά) ήπιες; (*2 drinks*)	______________________
13b.	What time was your last caffeinated drink? Τι ώρα ήπιες το τελευταίο σου ποτό με περιεκτικότητα σε καφεΐνη (καφές, τσάι, κόκα κόλα, ενεργειακά ποτά); (*16:30*)	______________________

14a.	Did you take any over-the-counter or prescription medication(s) to help you sleep? Έχεις πάρει υπερδοσολογία ή φαρμακευτική αγωγή για να σε βοηθήσει να κοιμηθείς;	□ yes	□ no
14b.	If so, list medication(s), dose, and time(s) taken. Αν ναι , γράψε ποιο φάρμακο-α, δόση, και τι ώρα το πήρες.	____________________	

15. Comments Σχόλια (if applicable)

____
____
____

Consensus Sleep Diary – M (Complete after waking up)

16.	What time did you get into bed? Τι ώρα πήγες για ύπνο; (*22:45*)	____________________	
17.	What time did you try to go to sleep? Τι ώρα προσπάθησες να κοιμηθείς;(*23:10*)	____________________	
18.	How long did it take you to fall asleep? Πόση ώρα σου πήρε να αποκοιμηθείς; (*10 min*)	____________________	
19.	How many times did you wake up, not counting your final awakening? Πόσες φορές ξύπνησες, χωρίς να υπολογίζεις την ώρα που ξύπνησες εντελώς; (*5 times*)	____________________	
20.	In total, how long did these awakenings last?Στο σύνολο ,η ώρα που ξυπνούσες πόσο διήρκησε; (*24 min*)	____________________	
21a.	What time was your final awakening?Τι ώρα σηκώθηκες τελικά; (*7:20*)	____________________	
21b.	After your final awakening, how long did you spend in bed trying to sleep? Αφού ξύπνησες τελείως , πόση ώρα ξόδεψες προσπαθώντας να κοιμηθείς; (*10 min*)	____________________	
21c.	Did you wake up earlier than you planned? Ξύπνησες νωρίτερα από ότι σχεδίαζες;	□ yes	□ no
21d.	If yes, how much earlier? Αν ναι, πόσο νωρίτερα; (*60 min*)	____________________	
22.	What time did you get out of bed for the day? Τι ώρα σηκώθηκες από το κρεβάτι;(*7:40*)	____________________	
23.	In total, how long did you sleep? Στο σύνολο, πόση ώρα κοιμήθηκες; (*8 hours*)	____________________	
24.	How would you rate the quality of your sleep? Πως θα βαθμολογούσες την ποιότητα του ύπνου σου;	□ Very poor □ Poor □ Fair □ Good □ Very good	

25.	How rested or refreshed did you feel when you woke-up for the day? Πόσο ξεκούραστος και αναζωογονημένος ένιωθες όταν ξύπνησες ;	□ Not at all □ Slightly □ Somewhat □ Much □ Very much
26.	How did the Actigraph-device influence your sleep? Πως η συσκευή Actigraph επηρέασε τον ύπνο σου;	□ Not at all □ Slightly □ Somewhat □ Much □ Very much
27.	Did you noticed the Actigraph-device while sleeping? Παρατήρησες την συσκευή Actigraph ενώ κοιμόσουν;	□ Not at all □ Slightly □ Somewhat □ Much □ Very much

APPENDIX D – Additional questions for the sleep log – pre-competition

8.	How important is the upcoming match for you? Πόσο σημαντικό είναι για σένα το επόμενο παιχνίδι;	□ Not at all important □ Slightly important □ Moderate important □ Very important □ Extremely important
9.	How important is the upcoming match for your team? Πόσο σημαντικό είναι για την ομάδα σου το επόμενο παιχνίδι;	□ Not at all important □ Slightly important □ Moderate important □ Very important □ Extremely important
10.	How important is the upcoming match for your club? Πόσο σημαντικό είναι για τον σύλλογό σου το επόμενο παιχνίδι;	□ Not at all important □ Slightly important □ Moderate important □ Very important □ Extremely important

APPENDIX E – Manipulation-check control group

Name:________________________ Date:__________

1a.	Did you used yesterday any technique for falling faster asleep? Χρησιμοποίησες χθές όποιαδηποτε τεχνική για να σε πάρει ο ύπνος γρηγορότερα?	□ No □ Yes, I used________________
1.b	For how many minutes did you used this technique last evening before going to sleep? Πόσα λεπτά χρησιμοποίησες αυτήν την τεχνική εχθές το βραδυ πριν πας για ύπνο;	_________________________
1c.	If yes, do you perceive the technique as useful? Εάν ναι, πιστεύεις ότι η τεχνική αυτή ήταν αποτελεσματική?	□ Not at all useful □ Slightly useful □ Moderate useful □ Very useful □ Extremely useful
2a.	Did you used yesterday any technique to relax? Χρησιμοποίησες χθές όποιαδηποτε τεχνική για να χαλαρώσεις?	□ No □ Yes, I used________________
2b.	If yes, made the technique it easier to relax? Εάν ναι, βοήθησε η τεχνική αυτή ώστε να χαλαρώσεις?	□ Not at all easy □ Slightly easy □ Moderate easy □ Very easy □ Extremely easy

APPENDIX F – Manipulation-check experimental group

Name:_______________________ Date:__________

1.	Did you used yesterday the breathing technique for falling faster asleep? Χρησιμοποίησες εχθές την τεχνική αναπνοής για να κοιμηθείς γρηγορότερα;	□ No □ Yes
2.	For how many minutes did you used the breathing technique last evening before going to sleep? Για πόσα λεπτά χρησιμοποίησες τη τεχνική αναπνοών χθες βράδυ προτού πας για ύπνο;	__________________________
3.	Do you perceive the breathing-technique from yesterday as useful? Θεωρείς την τεχνική αναπνοών που εφάρμοσες χθες χρήσιμη;	□ Not at all useful □ Slightly useful □ Moderate useful □ Very useful □ Extremely useful
4.	Made the breathing technique it easier for you to relax? Σε βοήθησε η τεχνική αναπνοών να χαλαρώσεις;	□ Not at all easy □ Slightly easy □ Moderate easy □ Very easy □ Extremely easy
5.	Was it easier for you falling asleep last night, because of the breathing technique you used? Σου ήταν πιο εύκολο να αποκοιμηθείς χθες βράδυ αφού χρησιμοποίησες τη τεχνική αναπνοών;	□ Not at all easy □ Slightly easy □ Moderate easy □ Very easy □ Extremely easy

APPENDIX G – Means and standard deviations of subjective and objective TST, WASO, SOL as well as sleep efficacy pre and post intervention

Figure G1: Differences in subjective and objective TST between pre and post intervention.

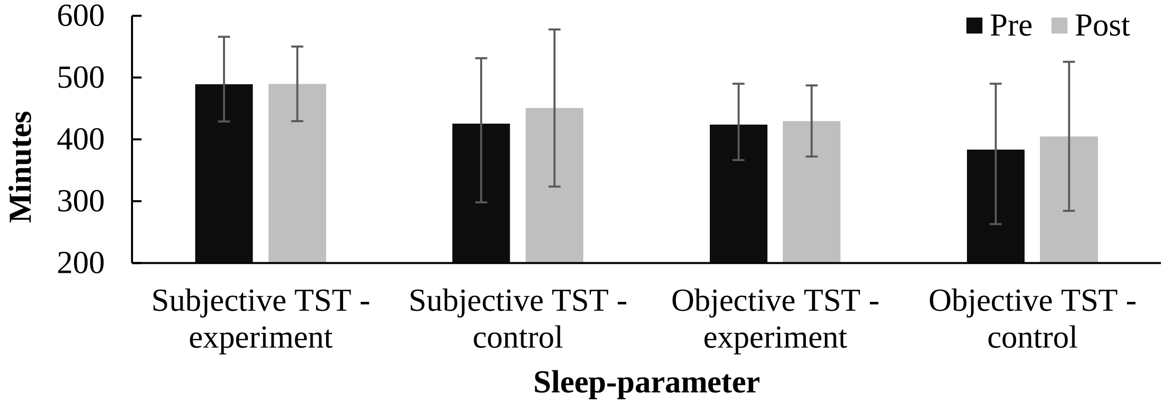

Figure G2: Differences in subjective and objective WASO between pre and post intervention.

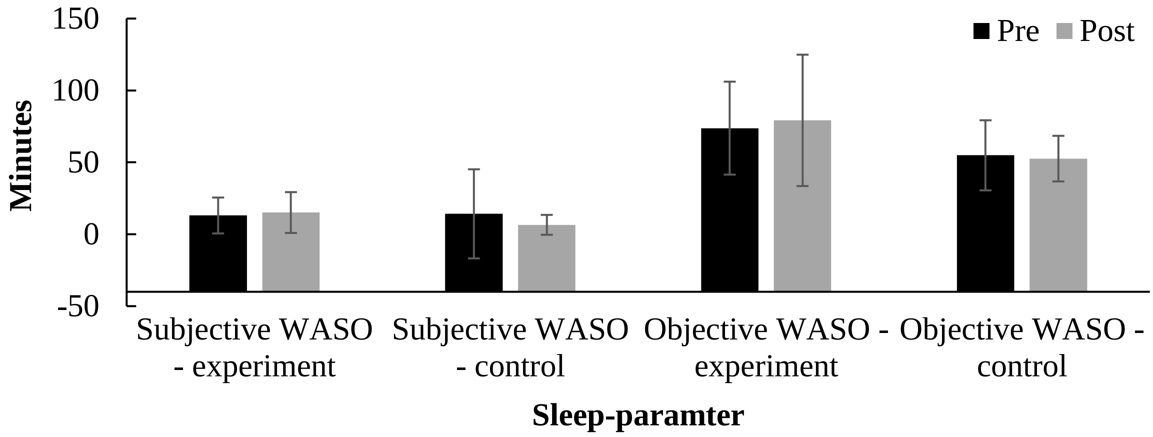

Figure G3: Differences in subjective and objective SOL between pre and post intervention.

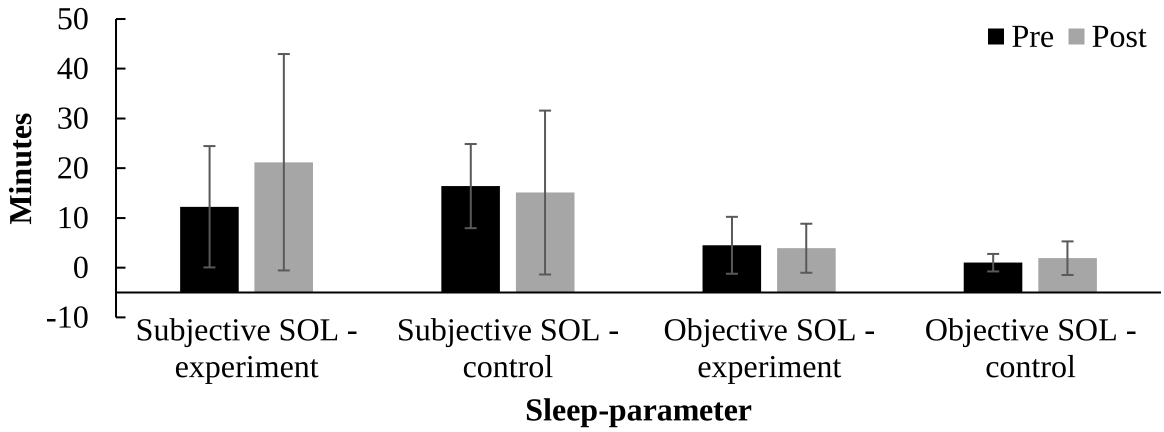

Figure G4: Differences in sleep efficacy between pre and post intervention.